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VOLUME 57
NUMBER 3

WHOLE NO. 263
1944

Psychological Monographs

JOHN F. DASHIELL, *Editor*

An Experimental Study of Punishment

By
WILLIAM K. ESTES

Published by
THE AMERICAN PSYCHOLOGICAL ASSOCIATION, INC.
Publications Office
NORTHWESTERN UNIVERSITY, EVANSTON, ILLINOIS

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AN EXPERIMENTAL STUDY OF PUNISHMENT

I. INTRODUCTION

THE SETTING[1]

IT IS a matter of everyday observation that a response which is followed by a disturbing or traumatic stimulus will tend to be weakened in strength and to be less likely to occur on subsequent occasions. In his original formulation of the law of effect, Thorndike stated that an annoying after-effect exerts a weakening effect upon the punished stimulus-response connection. As a general descriptive principle, this statement has never been seriously questioned. Most experimenters have found that punishment for 'errors' in learning situations tends to improve performance (1, 2, 4, 10, 11, 12, 13, 14, 15, 28, 35, 39, 54, 55, 56, 57, 59). Likewise, in the classical conditioning situation, it has been shown that a conditioned response is weakened by punishment (5).

Although the general tendency for punishment to weaken a response has been clearly established, the specific mechanism through which it acts has been a matter of dispute for more than a decade. As a result of a long series of experiments, Thorndike has revised his original formulation, and now believes that an annoying after-effect of a connection does not exert a direct weakening effect comparable to the strengthening effect of a reward; when a response appears to have been weakened by punishment, it is only because the organism has been forced to learn some alternative response to the situation (50). Unfortunately, however, the evidence on which Thorndike has based this conclusion is not unequivocal; he has generally used very mild 'punishments' (frequently mere lack of reward) and has dealt only with complex situations invoking many alternative responses. Although Thorndike's revised formulation has been generally accepted, several recent investigators have produced evidence favoring the original law of effect (6, 8, 43, 45). Hilgard and Marquis summarize the present status of the problem as follows:

> The action of punishment is a subject urgently needing additional research. It is not clear at present whether inhibition by punishment can be accounted for in terms of interference from responses established by the noxious stimulus or whether it represents a different and independent form of inhibition (25, p. 126).

THE PROBLEM

The first question to be investigated in the present study will be the effects of punishment upon the dynamic properties of the punished response. As we have already noted, it is well known that a response can be weakened in strength as a result of an annoying after-effect regardless of the specific mechanisms involved. But it remains to be determined whether the weakened response is actually eliminated from the organism's repertoire by punishment, or merely suppressed and capable of being released at its full original strength after punishment is discontinued. An exploratory investigation of negative reinforcement reported by Skinner (42) favors the latter possibility. And the clinical psychologist has long been aware of the significance of behavior which is prevented from occurring overtly ('repressed') because of

[1] This monograph is a revision of a doctoral dissertation submitted to the graduate faculty of the University of Minnesota in June, 1943.

its consequences, but which continued to exist in the organism's repertoire at a considerable state of strength. A number of the experiments which will be reported on the following pages deal with the changes in strength of a single isolated response produced by various combinations of positive and negative after-effects.

In the second portion of the investigation we shall be concerned with the clarification of the mechanism of action of punishment by means of an experimental analysis of the functional interrelationships of the variables operating in situations involving punishment.

After the derivation of the empirical principles governing the action of punishment upon a single response, an attempt will be made to determine whether additional principles will be required to account for the effects of punishment in more complex situations.

A NOTE ON METHOD

The results of an experiment can be evaluated only in the light of the measures which have been taken to ensure functional isolation of the variables under consideration. The only completely satisfactory method of achieving such isolation is control of irrelevant variables. However, psychologists have frequently been unable to secure satisfactory control of experimental conditions and have resorted to the use of large numbers of subjects in the hope that the effects of uncontrolled factors would tend to average out. In the present study it has been necessary for several reasons to rely principally upon experimental control. It appeared likely that many important quantitative properties of punishment would be revealed only under conditions of rigorous experimental isolation of the behavior studied. And in order to investigate the relatively permanent effects of punishment under varying conditions it was necessary to obtain a large number of responses from each subject over a considerable period of time, a procedure which was for practical reasons incompatible with the use of a large number of subjects.

In addition to the techniques of experimental control, which will be described in detail later, the general design of the investigation and the statistical analysis of the data are pertinent to an evaluation of the results. The various experiments described are "interlocking" in character, so that nearly every conclusion drawn from the entire study is supported by the results of at least two different experiments. Wherever feasible, statistical tests of significance, usually Student's "t" test, have been applied. It has been assumed that whenever the probability attaching to the value of "t" yielded by two sets of measures is less than 0.05 the possibility that the observed difference is due solely to sampling errors can be safely disregarded.

SUBJECTS AND APPARATUS

The subjects in all of the experiments to be reported were albino rats from the Minnesota laboratory stock. The groups of animals used in different experiments varied somewhat with respect to age, sex, and genetic history. Within each experiment, however, the experimental and control groups have been equated with respect to all of these factors.

The apparatus used has been described in detail by Heron and Skinner (24). During each experimental period each rat was enclosed in a light-proof and nearly sound-proof box containing a retractable lever which could easily be depressed and a magazine which could be set to reinforce responses to the lever by

releasing small (0.05 gr.) pellets of food into a food tray at one end of the box. A curve, number of responses vs. time, was recorded kymographically for each rat. An electric shock, the "punishment" in these experiments, could be delivered by a condensor through the wire grid which formed the floor of the experimental cage. The duration of the shock was but a fraction of a second. The tone used in one experiment was produced by phones attached to a sixty cycle AC transformer.

GENERAL PROCEDURE

While on an experimental routine, the animals were always fed dry Purina dog food for one hour immediately after the day's experimental session. Experimental periods were one hour long except where otherwise specified. Water was available in the living cages at all times. It was not possible to control the temperature of the living quarters completely; therefore comparisons of results of different experiments have been made only in cases where temperature variations could safely be assumed to be inconsequential.

The lever-pressing response is routinely conditioned under the following procedure. The rat is first placed in the experimental box for a one-hour period during which food pellets are periodically released by the magazine and the rat learns to respond promptly to the click of the magazine by approaching the food tray and seizing the pellet. On the day of conditioning, the rat is again placed in the box; the lever is now present and connected with the magazine so that responses to the lever will be reinforced with food. When, in the course of exploratory activity, the rat "accidentally" moves the lever, a pellet of food is released into the food-tray, and typically the rat soon comes to respond at a constant rate. It should be noted that any movement which results in depression of the lever counts as a response. Most rats form the habit of rising and striking the lever with the fore-paws.

After preliminary conditioning, each rat was given several hours of periodic reinforcement before being used in an experiment. Under this procedure, a control clock is set to reinforce single responses to the lever every four minutes, intervening responses going unreinforced. Except where specified otherwise, the preliminary training of all rats used in the following experiments consisted of initial conditioning and two or three hours of periodic reinforcement (just enough to produce a stable rate of responding).

SYMBOLIC NOTATION

The following notation will be used throughout the paper. R, response; S, stimulus; S^D, discriminative stimulus; S^R, reinforcing stimulus; S^P, disturbing or traumatic stimulus; $\bar{x}_E$, mean number of responses for experimental group during a given period; $\bar{x}_C$, mean number of responses for control group during a given period; "t", Student's "t-ratio", i.e., the ratio of a mean difference to an estimate of its standard error; P_t, the probability that a value of "t" as large as that observed would occur in a random sampling distribution; N, number of subjects; Pr., periodic rate (in terms of number of responses per hour); T_{1-x}, total number of responses during the first x experimental periods.

II. Basic Experiments

Outside of the laboratory, punishment occurs in two general types of situation. In the first, the punishment results mechanically from every occurrence of the response during the lifetime of the organism (e.g., the negative reinforcement produced by touching a hot radiator). In the second, punishment is administered, usually through the mediation of another organism, for making some specific response during a limited period of time (e.g., punishment of a child for going into the street). Since the former situation involves no peculiar theoretical problems, only the latter, and probably more general, case will be subjected to experimental study.

In the practical control of behavior, reward is usually discontinued when punishment is administered; however, in some instances, this is difficult or impossible (e.g., in the punishment of criminals), so both conditions will be considered in this chapter.

Section 1. The Effects of Varying Conditions of Punishment of a Response upon the Course of Subsequent Extinction

The experiments to be described in this section were designed to provide at least partial answers to these questions:

1. What are the effects of punishing a response upon the course of subsequent extinction?
2. To what extent are these effects a function of the conditions of punishment and the initial strength of the response?

In the first situation to be considered, a response which was previously positively reinforced is punished during a limited period of time, then during subsequent periods is neither punished nor reinforced. Some of the problems which arise are illustrated by the diagram in Figure 1. Let us assume that two groups of animals have been positively reinforced for emitting some specific response and that they have attained equal mean rates of responding under periodic reinforcement as shown on Day 1 in Figure 1. Then, beginning on the following day, reinforcement is discontinued for the control group and all responses go unreinforced thereafter. Skinner's studies (42) show that the rate of responding

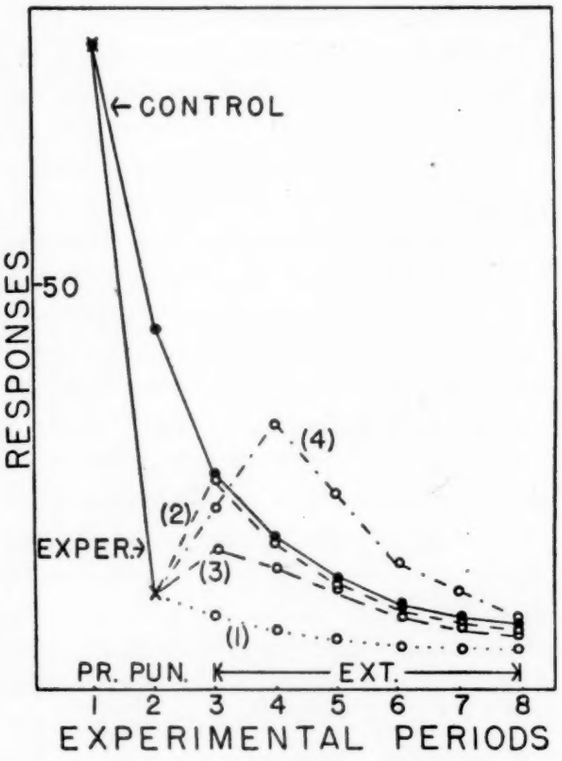

Fig. 1. Paradigm of possible effects of a single period of punishment upon the course of subsequent extinction.

during subsequent periods will decline regularly for this group in a negatively accelerated curve and will continue to decline until a permanently low rate (slightly above zero) is reached and the response is said to be extinguished. That is, effectively it is no longer a part of the organism's repertoire.

Now let us turn to the experimental group. On Day 2 (Figure 1) the experimental animals are severely punished for each response and the rate quickly falls to nearly zero. Superficially, it appears that by the use of punishment a state of extinction of the response has been reached in one day which required more than eight days for the control group under conditions of simple non-reinforcement. But in the case of the experimental group is the strength of the response at the end of Day 2 a reliable index of the true state of its dynamic properties? That is, if these rats are returned to the situation on subsequent days as were those of the control group, will the rate of responding (1) continue at a low value; (2) rise immediately after the termination of punishment to the rate which would have obtained if no punishment had been administered; (3) recover gradually on subsequent days until at some later point the curve rejoins that of the control group; or (4) during recovery rise above the rate of the controls for a time so that the total number of responses occurring during extinction is equal to that which would have appeared if no punishment had been administered?

Only if alternative (1) proves to be correct will we be able to conclude that punishment accelerates the process of extinction of a response from an organism's repertoire. Any other result will indicate that punishment results in a suppression rather than an elimination of behavior. The other possible continuations do not affect the total amount of time required for extinction, and differ among themselves chiefly in the extent of reduction

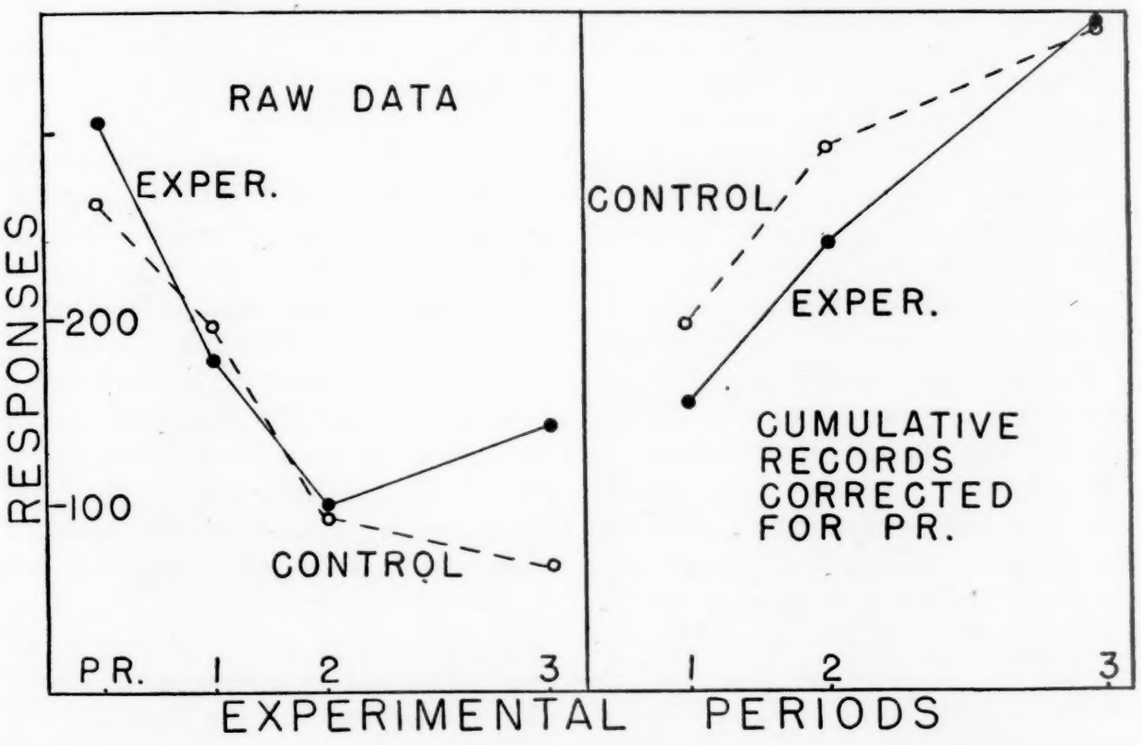

FIG. 2. Effects of a short period of mild punishment upon extinction. Punishment was administered to the experimental rats from the fifth to the twentieth minute of Period 1. The left hand panel shows the mean periodic rates and extinction records in terms of the raw data; in the right hand panel the mean extinction curves have been corrected for differences in periodic rate and plotted cumulatively (Experiment A).

in the total number of elicitations of the response necessary for extinction.

Experiment A. Effects of Mild Punishment upon Extinction

Throughout the present study, the severity, or intensity, of the punishment is judged by its momentary effect upon the animal's behavior. In the present stage of our knowledge, physical measures of the intensity of a negatively reinforcing stimulus have relatively little psychological meaning. Two widely separated intensities of shock are studied in this investigation. The 'mild' punishment is a shock just strong enough to produce a reliable depression in the rate of responding and not strong enough to produce complete inhibition of the response, even when continued for an hour or more. The 'severe' punishment is a shock which results in a decline in rate of responding to virtually zero within a few minutes. The following experiment investigates the effects of a short period (15 minutes) of mild punishment.

Subjects and Procedure. The subjects, sixteen male rats, were divided into an experimental and a control group of eight rats each after preliminary conditioning and periodic reinforcement. On the first day of the experiment proper, both groups received one hour of extinction of the pressing response. From the fifth through the twentieth minutes of this period, the experimental animals were punished for responding. The condensors were connected in circuit with the levers and the grid floor of the experimental boxes so that when the condensors were set, depression of the lever released a shock through the grid. During the fifteen-minute period of punishment, the shocking apparatus was reset every thirty seconds. Thus, not all responses were punished, but many were. A second hour of extinction without punishment was given both groups twenty-four hours after the first and a third forty-eight hours after the second.

Results. The course of the experiment is shown graphically in the left hand panel of Figure 2, and the quantitative results are summarized in Table 1. It will be noted that the experimental rats had a somewhat higher mean periodic rate than the controls.

TABLE 1
Mean periodic rates and extinction records for Experiment A

	Pr.	Extinction Periods			
		1*	2	3	T
$\bar{x}_E$	308	181	99	145	425
$\bar{x}_C$	264	198	97	67	362
t		.34	.06	3.02	
P_t		.72	.90	.01	

* During the fifteen-minute interval of punishment in Period 1, the mean number of responses for the experimental group was 45, of which 9.25 were punished; the corresponding value for the control group was 58 responses.

The immediate effect of the shock was a gradual decrease in rate of responding. By the end of the interval of punishment, the rate for the experimental rats had dropped considerably below that of the controls. After termination of the shock, the strength of the response began to recover within a few minutes, and by the end of the hour was about equal to that of the controls. These effects are illustrated by a mechanically averaged kymograph record for four of the experimental rats reproduced in Figure 2a. The two groups produced about the same numbers of responses on the second day of extinction; on the third day the experimentals exceeded the controls by an amount sufficient to compensate fully for the deficit incurred on the day of punishment.

The higher periodic rate of the experimental rats indicates that they probably had a slightly higher average motivational level than the controls. In order to gain a more accurate estimate of the extent of compensation for the temporarily depressing effect of punishment, the extinction record for the experimental group has been multiplied through by a constant chosen to equate the groups for initial periodic rate and plotted as a cumulative curve, along with the corresponding control record, in the right hand panel of Figure 2. A comparison of the corrected curves for the two groups indicates that for the condition of punishment used in this experiment, the course of subsequent extinction is correctly described by Curve (4) in Figure 1. This result strikingly confirms an

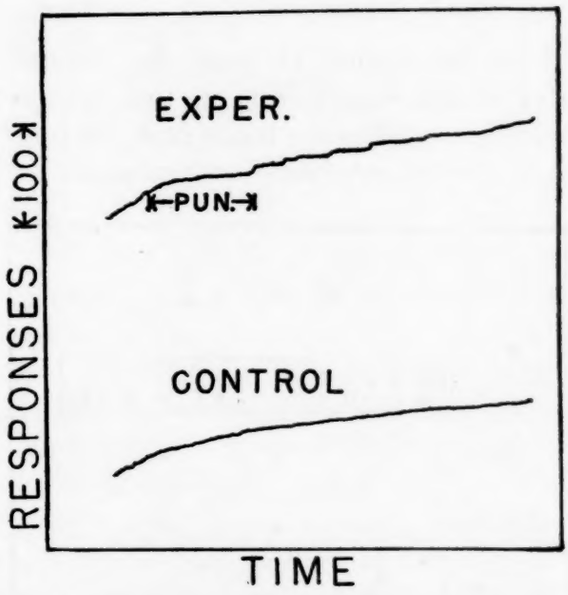

FIG. 2a. Reproduced from photostatic copies of mechanically averaged kymograph records of four experimental and four control rats for Period 1. The interval during which the experimental animals were punished is indicated (Experiment A).

experiment reported by Skinner (42). Skinner found that a short period of mild punishment (consisting of a slap administered to the rat's forepaws by a "kick-back" of the lever) resulted in a temporary depression in rate of responding followed later by complete compensation.

Conclusion. The effect of a short period of mild punishment is a temporary depression in rate of responding, followed later by a compensatory increase in rate such that the total number of elicitations of the response necessary for complete extinction is equal to that which would have been required if no punishment had been administered.

Experiment B. Effects of a Short Period of Severe Punishment upon Extinction

The interval of punishment used in this experiment was just long enough to allow the mean rate of responding of the punished animals to drop to virtually zero. Judged by its effect upon the momentary behavior of the rats, the shock was distinctly more severe than that used in Experiment A. This intensity was held constant throughout the remainder of the investigation, since it appeared that important properties of punishment would be revealed more clearly at high intensities.

Subjects and Procedures. Nineteen rats were subdivided as follows after preliminary training:

Group	N
Part 1	
A (Experimental)	5
B (Control)	5
Part 2	
C (Experimental)	5
D (Control)	4

In the present discussion, the two parts of the experiment will be treated as essentially two replications of the same experiment. The significance of a minor difference in procedure on the day of punishment will be taken up in the next

TABLE 2
Mean number of responses per experimental period under conditions of periodic reinforcement, punishment, and extinction (Experiment B)

	N	Pr.	Pun.	Extinction Periods					
				1	2	3	4	5	6
				Part 1					
$\bar{x}_A$	5	336.6	15.8	115.2	103.2	91.0	57.0	60.6	51.0
$\bar{x}_B$	5	365.0	76.4	207.6	124.4	102.6	63.0	43.8	42.6
t			4.10	2.14	.51	.30	.24	.65	.74
P_t			.003	.07	.64	.77	.82	.53	.49
				Part 2					
$\bar{x}_C$	5	260.9	20.0	79.4	66.6	58.6	28.0	32.2	32.2
$\bar{x}_D$	4	196.6	70.8	133.3	78.5	58.8	61.0	43.8	37.8
t			1.47	1.29	.43	.01	1.32	.90	.45
P_t			.18	.24	.68	.90	.22	.40	.57

section of the paper. On the first day of the experiment proper, all four groups were placed in the boxes for a ten-minute period[2] during which they were subjected to the following procedures:

Group A: Punishment of all responses in addition to continued periodic food reinforcement

Group B: Periodic food reinforcement

Group C: Extinction with all responses punished

Group D: Extinction.

From the second through the seventh day of the experiment, all four groups were returned to the boxes daily for one-hour periods of simple extinction.

[2] Preliminary experimentation showed that with the intensity of shock used a ten-minute interval of punishment was long enough to produce temporary suppression of the responses in all cases but not long enough to permit any perceptible recovery from the initial effect.

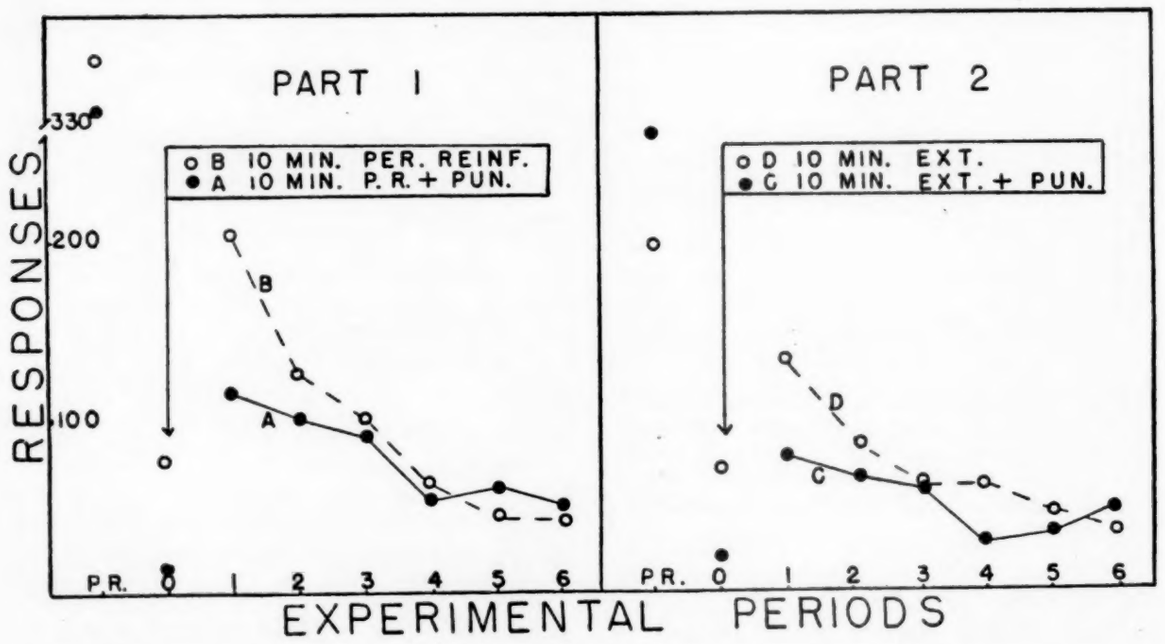

FIG. 3. Effects of a short period of severe punishment upon extinction. The initial depression in rate of responding resulting from punishment is followed by gradual recovery until the experimental curves rejoin those of the controls (Experiment B).

Results. The results of the experiment are summarized in Table 2 and illustrated graphically in Figure 3. The immediate effect of the punishment was a rapid decrease in the rate of responding until all of the experimental animals had ceased responding entirely by the end of the ten-minute period of punishment. The initial effect is illustrated by the individual record for one of the experimental rats of Part 2 reproduced in Figure 3a. It will be noted that the total number of responses made by the experimental rats was only a small fraction of the number produced by the controls during this period. On the first subsequent day of extinction, the rate of responding of the experimental animals was still markedly depressed. By the fourth day, however, the momentary strength of response for the experimentals was approximately equal to that of the controls. During the last three days of extinction, the experimental and control groups did not differ significantly. Although both experimental curves exhibit slight compensatory increases during the latter stages of extinction, compensation is by no means complete, and the total heights of the experimental curves are somewhat reduced as compared to the control records. The general picture corresponds to Curve (3) of Figure 1.

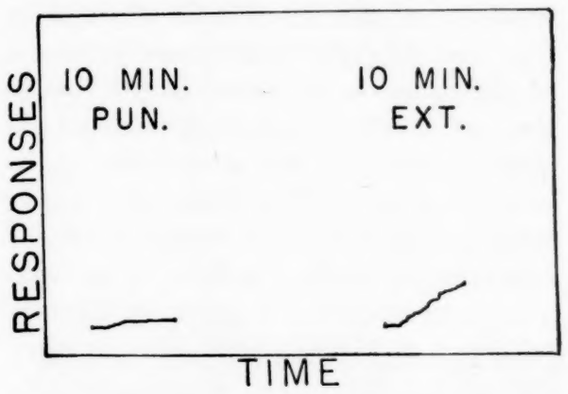

FIG. 3a. Reproduced from photostatic copies of the curves of an experimental and a control rat on the day of punishment (Experiment B, Part 2).

The close agreement of the two parts of the experiment with respect to the course of recovery from punishment suggests that the form of the process may be well enough established by these data to permit a mathematical description.

Let us take as a convenient index of the effect of punishment during any given extinction period the difference between the heights of the experimental and control curves, expressed as a proportion of the latter. That is,

$$p = \frac{\bar{x}_C - \bar{x}_E}{\bar{x}_C}$$

Although this index is not entirely satisfactory, it is probably the best one available at present. It is to be expected that the extent to which a mathematical analysis of the effects of punishment can be fruitfully carried will be limited until an extensive mathematical treatment of conditioning and extinction has been completed. The observed values of p for the two parts of the experiment are plotted against time in Figure 4.

Choice of a simple mathematical function to describe the recovery process must be guided by several known conditions in addition to the trend of the empirical points in Figure 4.

1. The form of the recovery process is, in part, a function of the severity of punishment (Experiments A and B).

2. Recovery is affected by individual differences in constitutional "reactivity" or "sensitivity" to the punishing stimulus (observed in all of these experiments).

3. The rate of recovery is probably a function, in part, of the amount of positive reinforcement of the response prior to the period of punishment (for experimental con-

firmation of this assumption see Experiment F).

Unfortunately, it is not yet possible to obtain independent quantitative estimates of the effects of these factors upon the rate of recovery. However, their effects can be taken into account by incorporating into the equation a measure of the initial effect of punishment which is in turn a joint function of these factors.

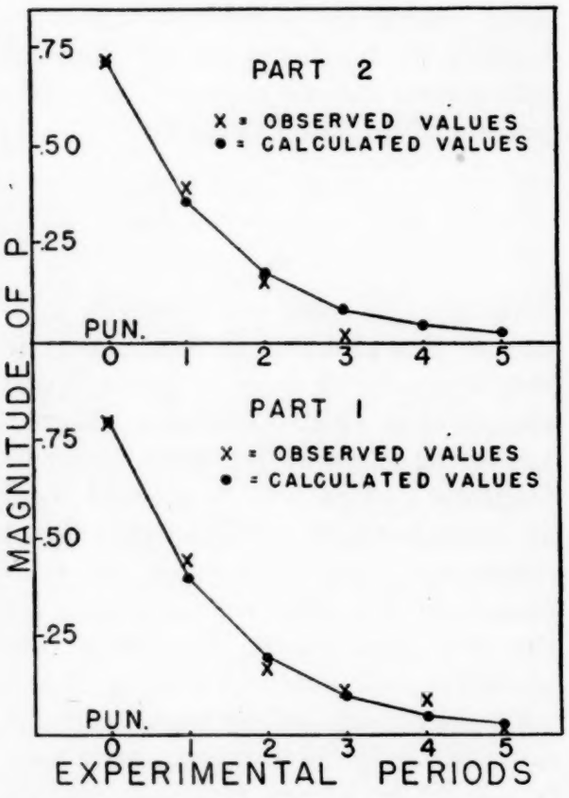

FIG. 4. The course of recovery from the depressing effect of a short period of severe punishment, including both theoretical and observed values of p, an index of the current effect of punishment (Experiment B).

A simple function which meets the above-mentioned conditions is an equation of the form

$$p_t = p_0 e^{-at} \qquad (A)$$

where P_0 is the value of p for the period during which punishment is administered, t is a measure of time in terms of the number of periods of exposure to the situation in which the punishment was administered, e is the base of Naperian logarithms, and a is a constant.

A curve of this form in which

$$p_0 = 0.7932$$
$$a = 0.6772$$

has been fitted to the first four empirical values of p for Part 1 of the experiment in the lower panel of Figure 4. The function chosen is evidently descriptive of the trend of observed points.

A preliminary test of predictive significance of this function is afforded by Part 2 of the experiment, since, by means of the equation, it should be possible in the case of other experiments carried out under conditions similar to those of the original to predict the course of recovery from punishment if a measure of the initial effect of the punishment is available. The theoretical curve in the upper panel of Figure 4 represents an equation of the same form as equation (A), in which the value of the constant of decrement, a, *is taken from the curve of Part 1*. It will be observed that the predicted and observed values of p for Part 2 of the experiment are in fair agreement, especially considering the small number of subjects used. The empirical points have not been plotted beyond the point at which the difference between experimental and control groups once reaches zero in either case. The extinction curves become so low by the third or fourth day that for small groups of animals the observed values of p must become very unreliable beyond this point.

Equation (A) is to be treated as an empirical rather than a rational equation. It will be possible in later experiments, however, to test the descriptive power of this function beyond the limits

of the data upon which it was based. It will be noted, for example, that according to Equation (A), recovery from the effects of punishment is never quite completed. With increasing time, the magnitude of p approaches zero asymptotically. It is impossible to confirm or refute this property of the equation in the present experiment since the effect remaining after three or four periods of extinction is so small as to be obscured by "chance" fluctuations. In Experiment C, in which the period of punishment is of considerably greater duration, it may be possible to test this implication of the equation, since the relatively permanent effect of punishment should in that case be large enough to be detectable under suitable conditions.

Conclusion. It appears that under the conditions of the present experiment, namely:

(a) that a response has been raised to a relatively high state of strength by periodic reinforcement; and

(b) that punishment is administered for a period of time just long enough to produce temporary suppression of the response;

the process of recovery from the effect of the punishment during subsequent periods in which the response is neither punished nor rewarded is described by the equation

$$p_t = p_o e^{-at}$$

where p_t is an index of the effect of punishment remaining at time t, p_o is a measure of the initial effect of the punishment, and a is an arbitrary constant.

It is probable that, under the conditions stated, the process of recovery from punishment will always proceed more rapidly than extinction of the response; therefore the effects of punishment will be almost completely dispelled at some point prior to the time at which extinction would have been completed in the absence of punishment. Subsequent to this point, the strength of the response will equal or exceed that which would have obtained if no punishment had been administered. The total amount of time required for complete extinction of the response will not, then be affected by the punishment, irrespective of its severity, although the number of elicitations of the response necessary for extinction may be reduced somewhat.

Experiment C. Effects of Prolonged Punishment upon Extinction

In Experiment B, the punishment was continued only until the rate of responding had dropped to approximately zero. In the present experiment, the punishment was carried beyond this point of temporary inhibition, so that when the response began to recover in strength later in the period, it was again punished. By the end of a sixty minute period of punishment, it appeared likely that the rate of responding would remain virtually at zero so long as the correlation of shock with response was maintained. In the vernacular, the animals had learned "that the administration of punishment was not merely a temporary matter."

Subjects and Procedure. The subjects for the two parts of the experiment were twenty rats subdivided as follows:

Group	N
Part 1	
A (Experimental)	4
B (Control)	5
Part 2	
C (Experimental)	5
D (Control)	6

After the usual preliminary training, the animals were subjected to the following procedures.

Part 1. On the first day of the experiment, Group B received one hour of extinction while Group A received an hour of extinction with all responses punished. Subsequently each group received four periods of simple extinction. The intervals between experimental periods were varied: between the first and second, one day; between the second and third, two days; between the third and fourth, four days; between the fourth and fifth, twenty days.

Part 2. On the first day, Group D received simple extinction of all responses for one hour, while Group C received an hour of extinction with all responses punished. Eight days later, both groups were returned to the boxes for further extinction. The second and third periods were separated by one day, the third and fourth by twenty days.

After the last extinction period, all four groups of animals were reconditioned[3] and given two more days of periodic reinforcement followed by three days of extinction in order to test for any permanent effects of the protracted punishment.

Results. A comparison of the experimental and control records of Part 1 (Figure 5 and Table 3) reveals little recovery from the effects of the long period of punishment. The extinction curve for Group A approaches the form of Curve (1) in Figure 1. However, the fact that in Part 2, where the same amount of punishment was used, the experimental curve rejoins that of the controls on the fourth day, suggests that the recovery process in the case of Group A was not entirely

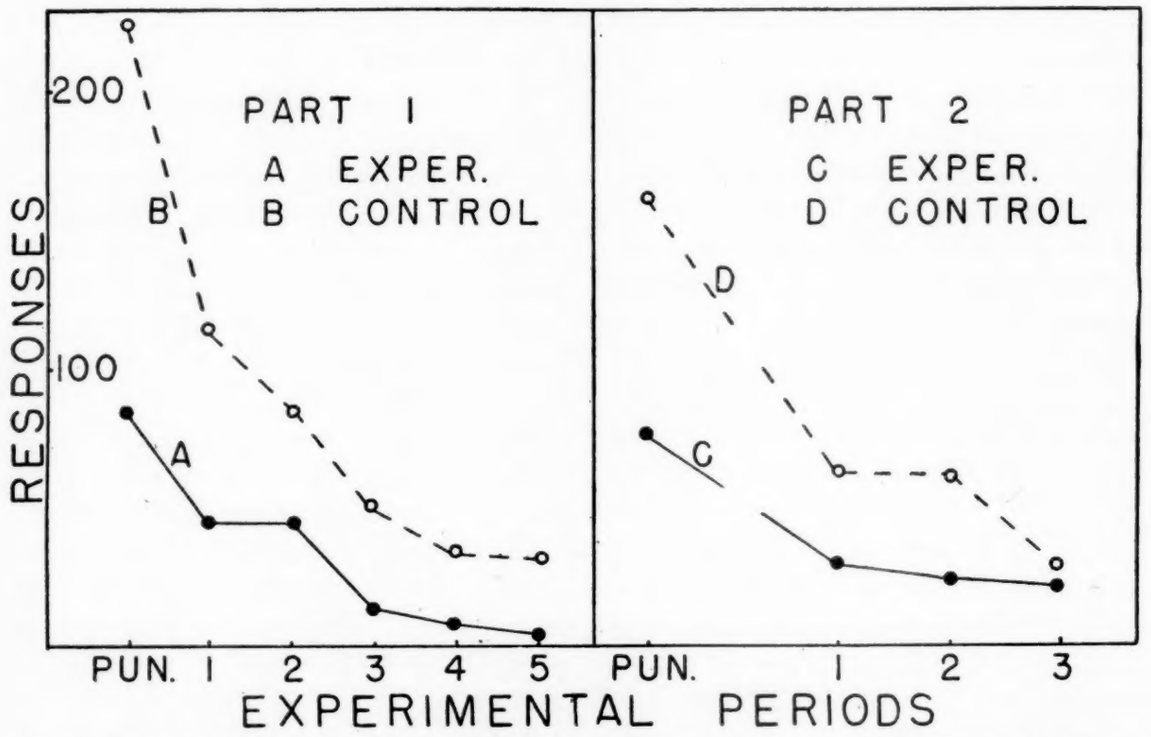

FIG. 5. Effects of a sixty-minute period of punishment upon extinction. In Part 2, extinction was not begun until eight days after the period of punishment, the depressing effect of punishment was not dispelled by a mere lapse of time (Experiment G).

[3] During the period of reconditioning each animal was reinforced for the first five consecutive responses emitted, than periodically reinforced for the remainder of the hour.

absent, but for some reason was delayed. This hypothesis is supported by the results of the reconditioning, and second extinction. A relatively permanent effect of the protracted punishment is indicated by the fact that Groups A and C have lower periodic rates and smaller extinction curves *after reconditioning* than the control groups, although they had exhibited higher periodic rates prior to the period of punishment.[4] However, during the hour of reconditioning after the first extinction (see Table 3), the animals of Group A averaged a considerably larger number of responses than the corresponding controls. This anomalous finding suggests that a number of responses in part by the temporal spacing of the extinction periods. In other experiments which involved long periods of punishment but in which the extinction periods were separated only by twenty-four hour intervals, recovery was considerably accelerated (e.g., Experiment F).

Except for the differences already noted, the results of Part 2 of the present experiment are similar to those of Part 1. The effects of punishment clearly were not dispelled by mere lapse of time between termination of punishment and the beginning of subsequent extinction. In fact it appears not unlikely that the affect of a lapse of time is to accentuate the effect of punishment.

TABLE 3

Quantitative data of Experiment C in terms of group means, including number of responses per hour during original periodic reinforcement, punishment, and extinction; total number of responses during first extinction; number of responses during the hour of reconditioning; periodic rate after reconditioning; total number of responses during second extinction

	Pr.	1 (Pun.)	2	3	4	5	6	T	Rec.	Pr.	$T_{ext.}$
						Part 1					
$\bar{x}_A$	453.1	84.8	46.0	47.5	15.8	8.5	5.8	208.4	236.5	140.8	188.8
$\bar{x}_B$	365.4	222.6	113.0	86.8	51.6	34.4	33.6	542.0	174.0	218.0	235.0
t	.54	1.41	3.31	2.27	2.20	5.52	2.84	2.26	.83	1.43	.67
P_t	.60	.20	.01	.06	.06	.001	.03	.06	.43	.19	.52
						Part 2					
$\bar{x}_C$	457.8	77.2	29.0	23.2	23.4			152.8	120.2	159.4	189.0
$\bar{x}_D$	378.2	161.5	63.5	63.0	28.2			316.2	239.2	242.9	239.0
t	.56	2.39	1.61	1.49	.48			2.50	1.25	1.14	1.31
P_t	.59	.04	.17	.17	.64			.03	.24	.30	.22

which had been suppressed by the severe punishment and which had not recovered sufficiently in strength to appear during the extinction periods were released when reinforcement was re-introduced and produced a temporary spurt in rate of responding.

It appears likely that the extreme delay in recovery from punishment in this experiment may be accounted for at least

Even with the amount of punishment used in this experiment, the strength of the response at the end of the period of punishment cannot be taken as an index of its true state. By the end of the hour of continuous punishment, it seemed almost certain that the rate of responding would remain very close to zero so long as punishment was continued. But during subsequent periods of extinction without punishment, the experimental animals emitted a substantial number of responses, even though the rate was con-

[4] This result confirms one implication of the equation developed in Experiment B, namely, that of a permanent effect of punishment.

siderably depressed as compared to the control record.

Conclusion. A response which has once been strengthened by periodic reinforcement cannot be eliminated from the organism's repertoire solely through the action of punishment. Although extreme instances may conceivably be found in which this principle breaks down, it is now well established for a wide range of conditions of punishment.

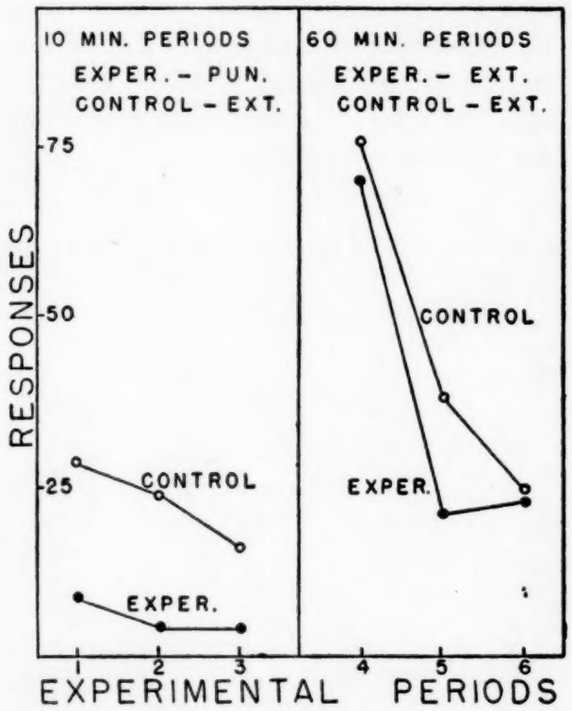

FIG. 6. Effects of several short periods of punishment. Note the abrupt recovery in strength of the response when punishment is discontinued (Experiment D).

Clearly, punishment results in a suppression rather than a weakening of the response. If extinction is carried out while the response is depressed in strength as a result of prolonged punishment, a considerable saving may be effected in the total number of elicitations of the response necessary for extinction. However, there is no evidence that the *time* required for complete extinction can be reduced by the action of punishment. In cases where punishment has apparently accelerated the extinction process, the suppressed behavior can still be released under suitable conditions.

Experiment D. Effects of Several Short Periods of Severe Punishment upon Extinction

The results of the preceding experiment suggest that a response cannot be eliminated from an organism's repertoire by a single period of continuous punishment irrespective of its duration. However, it may be that repeated periods of punishment might accomplish what one period cannot. The following experiment was designed to test this possibility.

Subjects and Procedure. After preliminary training, eight rats were divided into an experimental and a control group, each including two males and two females. On each of the first three days of the experiment proper, both groups were placed in the experimental boxes for a ten-minute period, during which the control rats received simple extinction while the experimental animals received extinction plus punishment for all responses. Both groups were given one hour of extinction daily on the fourth, fifth, and sixth days of the experiment.

Results. The immediate effects of punishment in this experiment (see Figure 6 and Table 4) are similar to those observed in Experiment B. During the first period of punishment, the rate of responding for the experimental group dropped to nearly zero. At the beginning of each of the next two periods, the strength of the response had "spontaneously" recovered somewhat but quickly dropped back to zero when punishment was continued. It is apparent that so long as punishment continues to follow all responses, the rate of respond-

ing can be held at a level equal to or less than that reached by the controls after six days of extinction.[5] When the punishment was finally discontinued, however, it was again demonstrated that punishment had not afforded a means of "shortcutting" the extinction process. The sharp rise in the experimental curve on the fourth day might even suggest that the action of punishment is governed by a law of diminishing returns the response required for extinction is reduced by this procedure by a number equal to the difference between the number occurring during the periods of punishment and the number which would have occurred during those periods under conditions of simple non-reinforcement. However, the *time* required for complete extinction is not altered by the punishment.

When a response has once been rein-

TABLE 4
Mean number of responses per experimental period under conditions of periodic reinforcement, punishment, and extinction (Experiment D)

	Pr.	Punishment			Extinction			$T_{Pun.}$	$T_{Ext.}$	T_{1-6}
		1	2	3	4	5	6			
		(10 min. periods)			(60 min. periods)					
$\bar{x}_E$	317.0	8.0	4.3	4.3	69.8	20.8	22.8	16.6	113.4	130.0
$\bar{x}_C$	268.5	28.3	23.8	16.3	76.0	37.3	27.3	68.4	140.6	209.0
t		2.73	3.35	6.03	.20	1.14	.63	4.34	2.68	1.31
P_t		.04	.01	.001	.85	.31	.62	.005	.04	.24

similar to that observed in the case of original positive reinforcement (42), and that recovery from the initial effect of punishment was proceeding concomitantly with the continued punishment during the second and third periods.

Conclusion. The effect of repeated periods of severe punishment is a suppression of the response which is maintained as long as the punishment continues to be correlated with the response. After discontinuation of the punishment, the strength of the response recovers to an extent such that during subsequent periods of extinction the rate of responding is about equal to that which would have obtained at the same time if no punishment had been administered. The total number of unreinforced elicitations of forced, there are definite limits imposed by the structure of the organism upon the extent to which external agencies can control the behavior by supplying or withholding punishments and rewards. Conditions intrinsic to the organism govern the maximum amount of behavior which will be available for elicitation during any given period of time. By the application of punishment, one can modify, almost at will, the number of responses during any single period of exposure to the situation in which the response can be made, but the total number of such periods necessary for elimination of the response cannot be modified.

Experiment E. Effects of Periodic as Compared to Continuous Punishment of the Response upon the Course of Extinction

Skinner (42) has shown that periodic

[5] The true difference between the two groups during the periods of punishment is probably greater than that indicated by Figure 6, since the experimental group had the higher rate under periodic reinforcement.

positive reinforcement of a response produces much greater resistance to extinction than continuous reinforcement. The following experiment was designed to determine whether a similar principle governs the action of punishment.

Subjects and Procedure. Two groups of rats, each including three males and two females, received the usual preliminary training before beginning the experiment proper. On the first day both groups were placed in the experimental boxes for a forty minute period, Group B receiving punishment for all responses while Group A was given periodic punishment under the following procedure. The period was divided into eight five-minute intervals. During the first, fourth, and seventh of these intervals, all responses were followed by shock, while responses occurring during the intervening intervals were neither punished nor reinforced. On the last five days of the experiment both groups were given one hour of simple extinction daily.

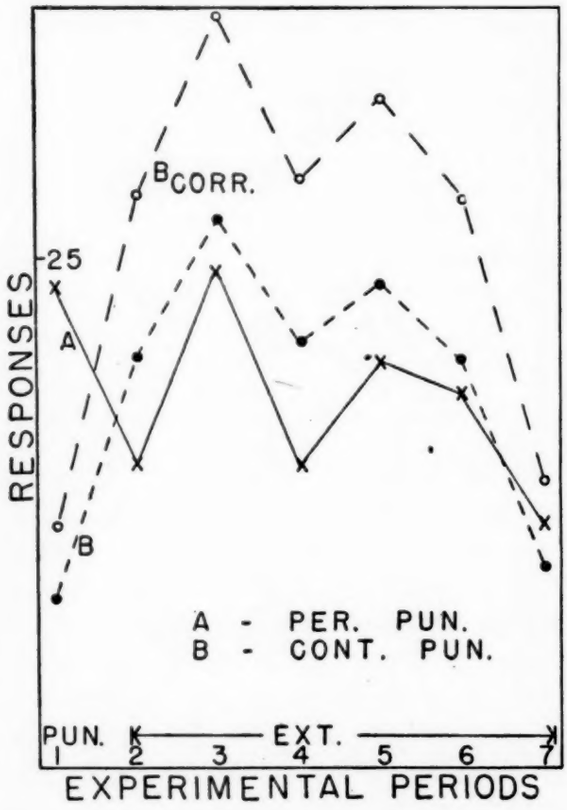

FIG. 7. Periodic vs. continuous punishment. The corrected curve for Group B, which received continuous punishment on Day 1, has been multiplied through by a constant chosen to equate the two groups with respect to periodic rate (Experiment E).

Results. The results are summarized in Figure 7 and Table 5. Clearly the procedure of continuous punishment produced a more rapid decline in rate of responding on the first day than periodic punishment, although the average number of punished responses was about the same for the two groups (Group A, 9.0; Group B, 8.5). During the subsequent extinction, on the other hand, Group A showed somewhat slower recovery. Since the two groups differed considerably in initial periodic rate, a curve corrected for periodic rate is included in Figure 7. The difference between groups on the first day yields a value of "t" which would be expected about nine times in a hundred through the operation of chance factors. On the remaining days of extinction, the trend is consistent although none of the individual mean differences are statistically reliable. Although the difference in the effects of the two conditions of punishment is not large, the observed difference can probably be accepted with confidence, since this result is confirmed by an independent experiment which will be reported later (Experiment K).

Conclusion. Continuous punishment produces a greater initial depression in strength of the response than periodic punishment; however, recovery from the effects of periodic punishment is clearly no more rapid than recovery from continuous punishment, and is probably somewhat slower. Again it is observed that the strength of a response at the end

of a period of punishment is not a reliable index of its true state.

Experiment F. Effects of Punishment upon Responses which Differ in Initial Resistance to Extinction

In exploring the effects of various conditions of punishment, we have dealt in each instance with behavior which existed at a state of considerable strength prior to the period of punishment. This is the case of most general interest since in the practical control of behavior the use of punishment is usually unnecessary if the response in question is not strong to start with. Likewise, in clinical psychology, one is concerned over the "repression" of a response only if it is strong enough to be a source of conflict. At this point in the present investigation, however, it is necessary to determine whether the effects of punishment upon initially strong and initially weak responses differ in kind or only in degree. The following experiment was designed to measure the effects of a period of severe punishment upon two responses which differ widely in amount of previous positive reinforcement.

Subjects and Procedure. The subjects were twelve female rats. After preliminary conditioning they were divided into three groups of four rats each; then, Groups A and B were given one hour and Group C five hours of periodic reinforcement. On the first day of the experiment proper, all of the animals were placed in the boxes for a forty-minute period during which Group B received simple extinction, while Groups A and C received extinction plus punishment for all responses. On the remaining four days of the experiment all groups received one-hour periods of extinction.

Results. Group A, which had received only one hour of periodic reinforcement, clearly shows a greater initial depression in rate of responding during the period of punishment and a slower recovery from the effects of the punishment than Group C (Figure 8 and Table 6). Group A had recovered sufficiently by the second day of extinction so that the rate of responding differed little from that of the control group during the remainder of the experiment. Group C recovered somewhat more rapidly and during the last three periods of extinction exhibited a compensatory increase in rate which partly made up the initial deficit caused by the punishment.[6] A comparison of these results with those of previous experiments indicates that the extent of later compensation for the initial depression in rate of responding resulting from punishment is dependent upon both the conditions of punishment and the amount of previous positive reinforce-

TABLE 5
Mean periodic and extinction records for Experiment E

	N	Pr.	Extinction Periods							
			1 (Pun.)	2	3	4	5	6	7	T_{2-7}
$\bar{x}_A$	5	152.6	23.8	15.0	24.8	14.8	20.2	18.6	13.0	106.2
$\bar{x}_B$	5	107.8	8.5	20.4	26.8	21.0	23.8	19.8	9.8	121.6

[6] The last three points on the curve of Group C would probably represent a compensatory increase even if compared with a control group which had also received five hours of periodic reinforcement. An unpublished study conducted by the writer indicates that such a control curve would not lie very far above Curve B.

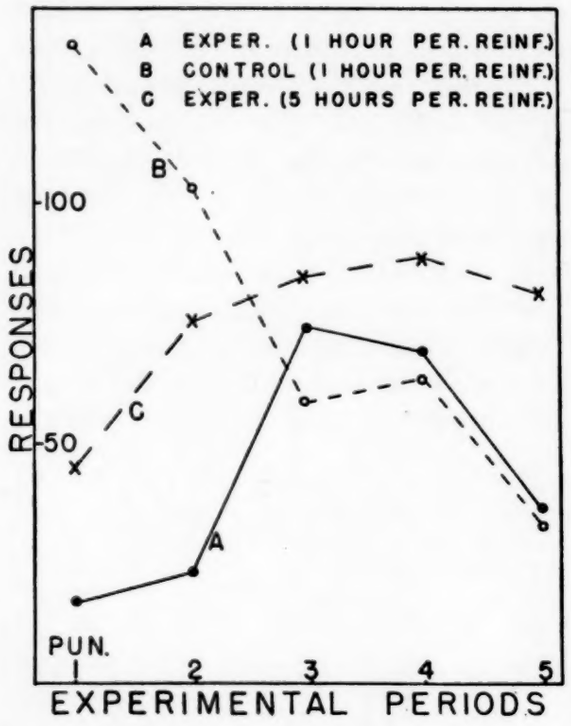

FIG. 8. Effects of punishment as a function of initial strength of the response. Groups A and B had received one hour, Group C five hours, of periodic reinforcement prior to Day 1 (Experiment F).

ment. The proportion by which the total number of elicitations of the response necessary for extinction can be reduced by a given condition of punishment decreases with increasing amounts of previous periodic reinforcement. The greater the initial strength of a bit of behavior, the less effective is punishment as a means of controlling it. It appears likely that with sufficient periodic reinforcement a strength of response could be achieved such that no period of continuous punishment, regardless of duration or intensity, would affect the total number of elicitations of the response required for complete extinction.

Conclusion. The extent to which the total number of unreinforced elicitations necessary for the complete extinction of a response can be reduced by punishment is a joint function of the amount of punishment and the amount of previous periodic reinforcement. With increasing amounts of periodic reinforcement, the resistance of a response to the effects of punishment probably increases more rapidly than the resistance to extinction.

Experiment G. Punishment of a Response After Establishment of a Discrimination

Since the preceding experiment demonstrated that the course of recovery from punishment is a function of the initial strength of the response when differences in strength have been produced by different amounts of periodic reinforcement, it is of interest to determine whether the same relations hold when differences in initial strength result

TABLE 6
Mean periodic rates and extinction records for Experiment F

	Pr.	Extinction Periods					
		1 (Pun.)	2	3	4	5	T_{1-5}
$\bar{x}_A$	210.3	16.5	23.0	74.3	68.5	38.3	220.6
$\bar{x}_B$	239.0	136.8	103.8	58.3	63.0	32.5	394.4
$\bar{x}_C$	291.8	44.3	75.0	84.8	88.5	80.5	373.0
B−A							
t	.37	6.41	4.47	.30	.18	.35	5.20
P_t	.72	.001	.004	.77	.86	.73	.002
B−C							
t	2.25	4.30	.92	1.08	.75	1.77	.25
P_t	.07	.005	.39	.32	.48	.13	.81

from the formation of a discrimination. The latter procedure should provide a rather delicate test of the relationship since it produces very low but stable states of strength.

It has been shown by Skinner (42) that a stimulus which characteristically precedes reinforcement of a response becomes an "occasion" for the occurrence of the response. For example, if a response is repeatedly reinforced when it occurs in the presence of a tone, but is never reinforced when the tone is absent, the response is gradually brought under the control of the tone (i.e., the tone becomes a discriminative stimulus for the response). If we designate the discriminative stimulus as S^D, the situation in the absence of S^D as S^N, and the response as R, then during discriminative training the correlation $S^N \cdot R$ decreases in strength while the correlation $S^D \cdot R$ increases, and the organism comes to respond at a much higher rate when the tone is sounding than when it is not. After several periods of discriminative training, $S^N \cdot R$ is virtually extinguished; $S^D \cdot R$ remains at considerable strength, but is much more readily extinguished than a response which has been merely periodically reinforced without differential correlation of the reinforcement with a discriminative stimulus.

The present experiment was designed to answer the following questions:

1. After the establishment of a discrimination, how will punishment administered in the absence of S^D affect the strength of the response in its presence?
2. Will recovery from punishment under the two stimulating conditions differ as should be expected according to the relation between initial strength of response and resistance to punishment formulated above (Experiment F)?

Subjects and Procedure. The subjects were eight rats divided into an experimental group of five rats and a control group of three. After preliminary training, the animals were given eight experimental periods of discriminative training under the following procedure. Every four minutes a tone was sounded in the experimental boxes; the next response to the lever released a pellet of food from the magazine and turned off the tone. Responses occurring during the silent intervals were unreinforced. By the end of the eighth day under this procedure, the discrimination was well established, as indicated by reduced latencies of response after onset of the tone and low terminal rates of responding in the absence of the tone (about 13 responses per hour per rat for the experimental group and 45 for the controls). After the completion of discriminative training, the experimental rats were given ten minutes in the boxes with all responses punished while the controls were given ten minutes of simple extinction. The tone was

TABLE 7
Mean number of responses during silent intervals and intervals when the tone was sounding (Experiment G)

	N	Extinction Periods							
		1: Pun.	2: Ext.	3: Ext.		4: Ext.		5: Ext.	
		S^N	S^N	S^N	S^D	S^N	S^D	S^N	S^D
$\bar{x}_E$	5	5.4	44.2	28.2	16.2	12.6	33.6	7.2	23.6
$\bar{x}_C$	3	28.3	170.0	65.0	64.7	26.7	62.3	21.3	31.0
t		4.26	2.71	3.71	5.81	1.62	1.85	1.47	.68
P_t		.005	.04	.01	.001	.15	.12	.20	.52

not present for either group during this period. On the following day both groups were given one hour of extinction without the tone. During three further periods of extinction, the tone was turned on for both groups according to the following schedule.

Second period.....the last 25 minutes,
Third Period .....the last 45 minutes,
Fourth period ....the last 45 minutes.

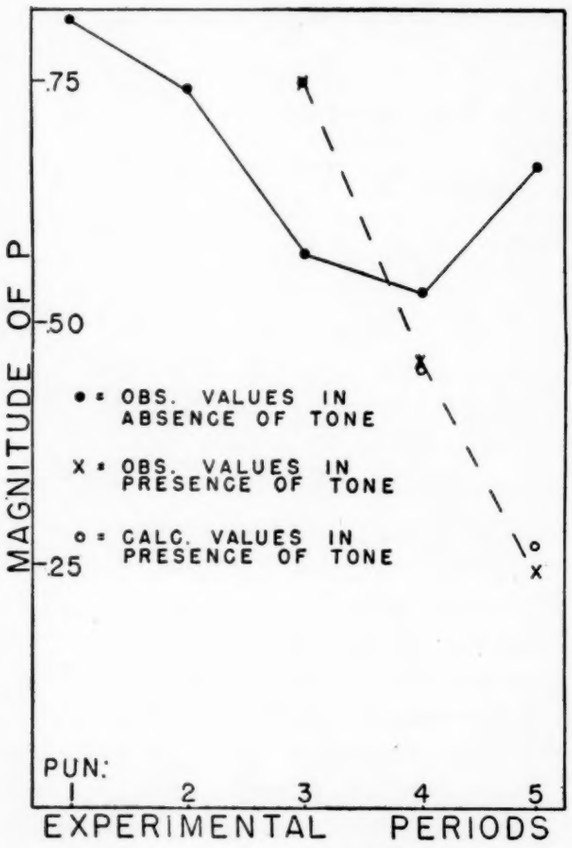

FIG. 9. Recovery from punishment during silent intervals and intervals when the tone was sounding. The magnitude of p is an index of the current effect of punishment (Experiment G).

Results. The results are summarized in Table 7. The course of recovery from the effects of punishment is shown graphically in Figure 9 where the measure of the effect of punishment during each experimental period is again taken as

$$p_t = \frac{\bar{x}_C - \bar{x}_E}{\bar{x}_C}$$

The solid line in Figure 9 represents the values of p for silent periods, while the broken line represents corresponding values of p for intervals when the tone was sounding.

The initial effect of punishment was apparently almost completely generalized from $S^N \cdot R$ to $S^D \cdot R$; the magnitude of P for the first interval of extinction when the tone was sounding (on Day 3 in Figure 9) was approximately equal to that for the first silent extinction period (Day 2 in Figure 9).

The course of recovery from punishment was quite different for the two stimulating conditions. There was little recovery in rate of responding in the absence of S^D. Recovery of strength in the presence of S^D, however, followed a course similar to that observed in Experiment B. Theoretical values of p for intervals when the tone was sounding have been calculated from equation (A) of Experiment B,

$$p_t = p_o e^{-at}$$

with the magnitude of the constant of decrement e^{-a} taken as 0.6. There is fair correspondence of observed and calculated values for the last two extinction periods; unfortunately, however, extinction was not carried far enough to provide an adequate test of the goodness of fit. On the last day of extinction, $S^D \cdot R$ had completely recovered from the effect of punishment, while $S^N \cdot R$ remained at a very low strength.

Conclusion. After the establishment of a discrimination between two stimulating conditions S^D and S^N, the initial effect of a short period of severe punishment of the response in the absence of S^D (i.e., condition S^N) is almost completely generalized to the strength of the response in the presence of S^D. Recovery in strength of the connection $S^D \cdot R$ follows a course similar to that observed in the case of a response which had re-

ceived simple periodic reinforcement prior to punishment. The strength of $S^N \cdot R$ exhibits very little recovery from the effects of punishment.

SECTION 2. CONFLICTING EFFECTS OF CONCOMITANT PUNISHMENT AND REWARD

A comparison of the effects of punishment administered after the discontinuance of reinforcement with the effects of punishment administered while the response is still being periodically reinforced is afforded by the two parts of Experiment B. On the first day of that experiment, one experimental Group (A) was given the usual periodic food reinforcement for pressing the lever and in addition was punished for all responses; in the case of the other experimental group (C), food reinforcement was discontinued while all responses were punished; the control groups (B and D) received simple periodic reinforcement or extinction. The results of the two procedures can be seen in Figure 3. It is clear that with the intensity and duration of punishment used in that experiment it makes little difference whether or not periodic positive reinforcement continues during the period of punishment. The extent of initial depression in strength of response was approximately the same for the two procedures. Moreover, the mathematical descriptions of the course of recovery from punishment in each instance indicates a similar form of the process in the two cases.

The course of recovery from punishment when the response continues to receive periodic reinforcement after the discontinuation of punishment is investigated in the following experiment. This case is of particular practical interest because punishment is most commonly resorted to as a means of influencing behavior when the factor of reward cannot easily be brought under control.

Experiment H. The Acceleration of Recovery from Punishment by Positive Reinforcement

Subjects and Procedure. The subjects were five male rats. After preliminary training the animals were subjected to the following procedure during a one-hour period. The control clock was set to reinforce single responses with food at four-minute intervals during the entire period (i.e., the usual procedure of periodic reinforcement); from the fifteenth to the thirtieth minutes of the hour all responses were punished.

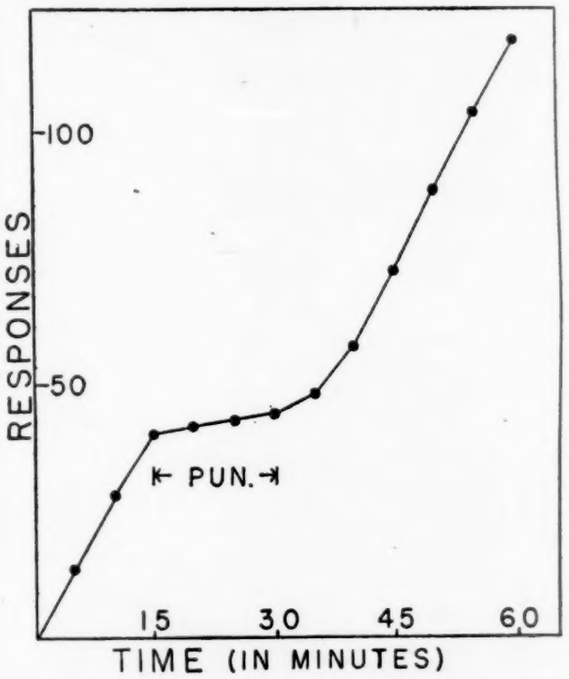

FIG. 10. Acceleration of recovery from punishment by positive reinforcement. Periodic food reinforcement at four minute intervals was given throughout the hour (Experiment H).

Results. The effects of the punishment and the course of subsequent recovery are shown in Figure 10. The initial effect of punishment under periodic positive reinforcement is a sharp decline in rate of responding similar to that observed

in Part 1 of Experiment B. However, the recovery in strength following discontinuation of the punishment is greatly accelerated in the present experiment where the after-effects of the punishment are in conflict with continuing positive reinforcement. The amount of time sub-

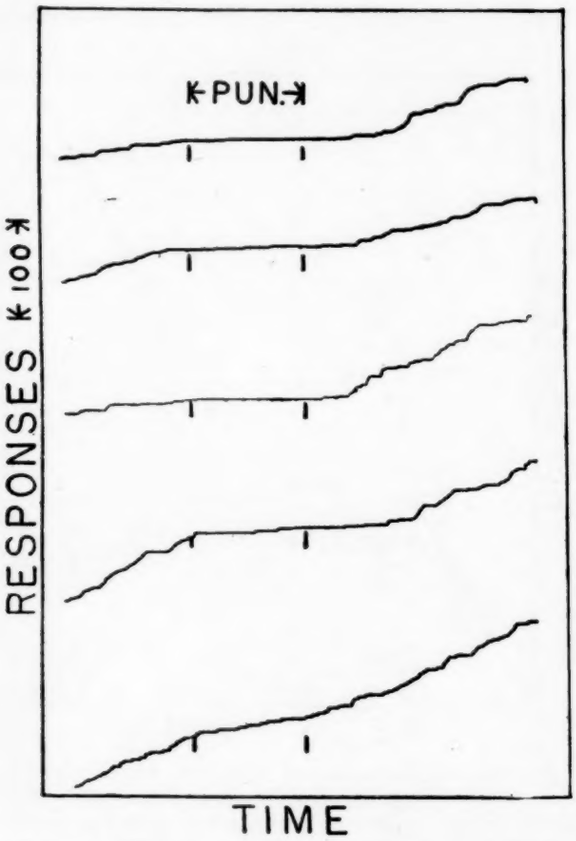

FIG. 10a. Reproduced from photostatic copies of the individual curves for the period which included the fifteen-minute interval of punishment (Experiment H).

sequent to the termination of punishment required for the rate of responding to regain the level which obtained before punishment is, in this case, approximately equal to the interval during which punishment was administered.

An important property of punishment is revealed by the behavior during the interval when the response was both punished and periodically reinforced. The rate of responding dropped sharply to a low value, about one-tenth of its former magnitude,[7] *it then remained constant* at this new low value until punishment was discontinued. The effect of punishment upon the periodic curve is simply a change in slope, in contrast to the negatively accelerated extinction curve which results from mere non-reinforcement. Although Thorndike (48, 50) and many of his followers (e.g., 31, 34, 43) have frequently used the terms "punishment" and "non-reward" almost interchangeably, it is clear that the two procedures may produce quite different effects upon the dynamic properties of the response.

In an earlier study reported by Skinner (42) a group of rats received periodic punishment (consisting of a slap to the forepaws administered by a "kick-back" of the lever) simultaneously with periodic food-reinforcement of a lever-pressing response throughout several experimental periods. The result was a temporary reduction in periodic slope, followed by a return to the slope which had obtained under periodic food-reinforcement alone. The differences between the results of Skinner's experiment and the present one are probably due to differences in severity of punishment. In the former case, the punishment was mild and the animals quickly became adapted to it; in the latter, the punishment was severe enough so that little adaptation would be expected.

The effects of punishment upon the strength of a response are very similar to those of a change in level of drive. Punishment of a periodically reinforced response results simply in an adjustment of the rate of responding to a lower, but still constant, value which is determined

[7] This effect can be seen most clearly in the individual curves of Figure 10a.

jointly by the conditions of reinforcement and the severity of the punishment. Likewise during extinction, punishment produces a depression in strength of the response which is maintained so long as the effects of the punishment persist. However progress toward complete elimination of the response is not accelerated while the strength is depressed because of punishment.

Conclusion. Concomitant punishment and reward of a response produce essentially the same changes in its dynamic properties as punishment after discontinuation of reward. The immediate effect of punishment upon a periodically reinforced response is a change in slope similar to that effected by a change in level of drive. If reinforcement continues after the discontinuation of punishment, the effect of punishment is quickly dissipated.

III. Analysis of the Action of Punishment

In any situation involving punishment, at least three principle variables can be distinguished: the response, R, discriminative stimuli for the response, S^D, and a disturbing or traumatic stimulus, S^P. The experiments reported in the earlier sections of this paper have, like most other psychological studies of punishment, investigated only the correlation between S^P and R or between S^P and $S^D \cdot R$ where the latter connection is taken as a unit. They have been concerned with punishment for doing something, the implicit assumption being that the effects of punishment are entirely dependent upon the temporal contiguity of the punishment and a response, and upon the punishment's being strictly contingent upon the occurrence of the response. In this chapter an attempt will be made to secure experimental confirmation or refutation of these assumptions.

Experiment I. Effects upon Extinction of a 'Punishment' not Directly Associated with the Response

The following experiment investigates the effects upon a response of correlation of a disturbing stimulus with the discriminative stimuli[8] for the response.

Subjects and Procedure. An experimental and a control group, of four rats each, were subjected, after preliminary training, to the following procedure. Both groups were placed in the experimental boxes for a ten-minute period of extinction, during which the experimental group received periodic shocks at intervals of approximately thirty seconds. Care was taken that the shock should not be given during or immediately following a response to the lever. Otherwise, the shocks were entirely uncorrelated with the response during this period. Beginning on the following day, each group was given six one-hour periods of simple extinction.

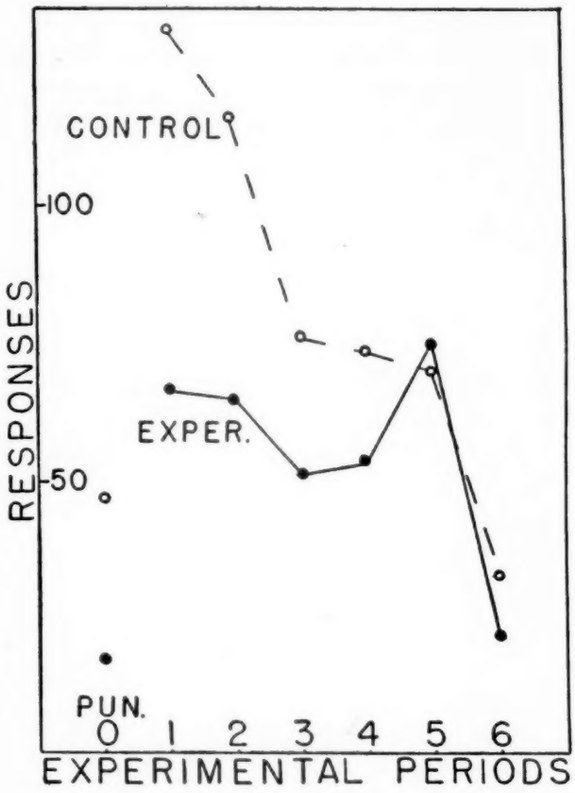

Fig. 11. Effects of periodic shocks upon extinction. On the day of 'punishment,' the experimental animals were given a series of shocks which were not temporally contiguous with responses to the lever (Experiment I).

Results. A comparison of the extinction curves for the experimental and control groups of the present experiment (Figure 11) with the corresponding curves for Experiment B in which the experimental groups had received ten minutes of punishment (Figure 3) reveals a striking similarity between the effects of a negatively reinforcing stimulus

[8] In this experiment the discriminative stimuli are merely the stimuli which are normally present in the experimental situation and which, after initial conditioning, provide the 'occasion' for the occurrence of the response.

which is uncorrelated with the response and one whose administration is contingent upon the occurrence of the response. In other words, merely being shocked in the experimental situation apparently has the same effect upon the animals' behavior with respect to the lever as being punished for making the response.

A more precise comparison of the two experiments is afforded by the mathematical descriptions of recovery from punishment in the two cases. In experiment B, it was found that recovery from punishment was described by an equation of the form:

$$p_t = p_o e^{-at}$$

where p_t is the magnitude of

$$\frac{\bar{x}_C - \bar{x}_E}{\bar{x}_C}$$

at the time t, p_o is the value of p for the period of punishment, and a is a constant. In Figure 12, an equation of this form with

$$p_o = .63$$
$$a = .21$$

has been fitted to the empirical values of p for the present experiment. The theoretical curve provides a good fit to the empirical points for the first four days of extinction. The last two points deviate from the expected value, but an average of the two would fall approximately on the curve. As noted above (Experiment B) this increased scatter toward the end of extinction is to be expected unless the number of subjects is very large because of the low terminal heights of the extinction curves. That is, on the fifth or sixth day, a chance deviation of only a few responses has a disproportionately large effect upon the value of p. And both in this experiment and in Experiment B, deviations from the theoretical curve tend to counterbalance each other in direction. That is, a marked deviation below the curve is followed by a compensatory rise above it. This phenomenon of compensation for deviations below a smooth curve representing the mean trend of a set of observed values has been frequently observed in connection with extinction curves (42). In any case, the theoretical curve in Figure 12 provides a satisfactory description of the trend of the observed points and the correspondence of calculated and observed values is probably better than could be obtained with any other simple mathematical function without increasing the number of arbitrary constants.

Since the effect of a shock which immediately follows a response (a 'punishment') upon the dynamic properties of that response is satisfactorily described by the same mathematical function which most simply describes the effect of a shock which is independent of the response, the conclusion seems inescapable that at least a great part of the initial effect of

TABLE 8
Mean periodic rates and extinction records for Experiment I

	N	Pr.	Extinction Periods							
			Pun.	1	2	3	4	5	6	T_{1-6}
$\bar{x}_E$	4	266.3	17.3*	66.5	65.5	51.5	53.8	75.5	22.3	335.1
$\bar{x}_C$	4	266.3	46.8	132.8	116.8	76.0	74.3	70.5*	33.3	503.7
t			2.33	2.11	1.64	1.30	1.26	.18	1.13	2.41
P_t			.05	.08	.15	.24	.25	.88	.30	.05

* Record for one rat during this period lost because of mechanical difficulty with the recorder.

punishment is due simply to correlation of the negatively reinforcing stimulus with the experimental situation. The important correlation appears to be that between the shock and the stimuli which normally act as the occasion for the occurrence of the response rather than between the shock and the response per se.

These results clearly confirm the contention of Thorndike (50) that the action of punishment is not a direct 'weakening' of the punished stimulus-response connection. Rather it appears that some part of the reaction to punishment becomes conditioned to the same stimuli which previously formed an occasion for the occurrence of the punished response, and that the empirical points of Figures 4 and 12 actually represent extinction curves for this conditioned reaction.

Conclusion. The temporal contiguity of a disturbing stimulus and stimuli which normally act as an occasion for the occurrence of a response yields a depression in rate of responding during subsequent periods of extinction very similar to that produced by actual punishment of the response.

Experiment J. Extinction of the Effects of Punishment Without Elicitation of the Response

The fact that little difference can be detected between the effects of a short period of punishment of a response and the effects of a comparable period during which the disturbing stimulus was administered independently of the response upon the course of subsequent extinction, indicates that a great part of the initial effect of punishment is attributable to the conditioning of a state of anticipation of the shock to the experimental situation and does not depend upon a close correlation of the shock with the response. If this interpretation is correct, it should be possible to extinguish the greater part of the effect of punishment, without elicitation of the response. The following experiment was designed to test this possibility by measuring the effect upon the course of recovery from

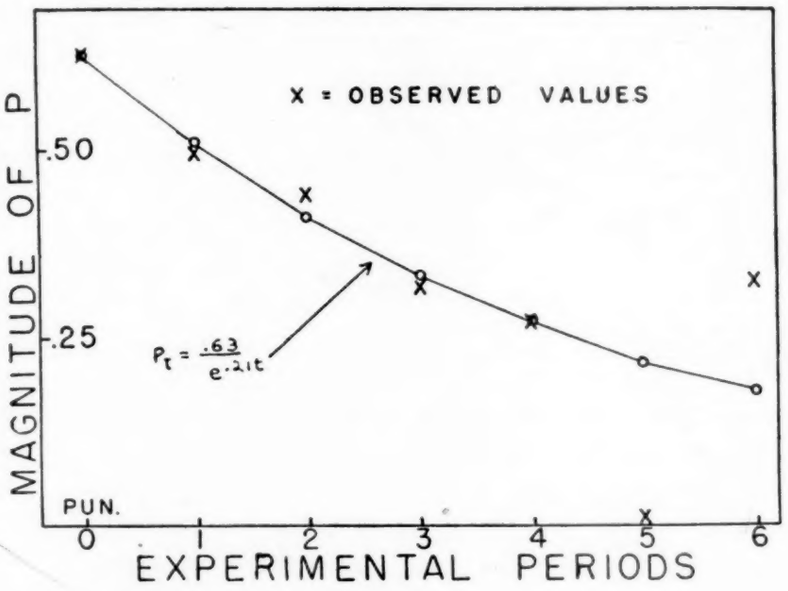

FIG. 12. Recovery from the effects of 'punishment' which was not correlated with the response. The magnitude of p is an index of the current effect of the 'punishment' (Experiment I).

punishment of the interpolation of a period of adaptation to the experimental situation between the period of punishment and the beginning of subsequent extinction. Part 1 of the experiment is purely exploratory; Part 2 is a replication with larger groups of animals and a slightly modified procedure.

Part 1

Subjects and Procedure. The subjects were three groups of rats, each including two males and one female. After preliminary training, the animals were subjected to the following procedure. During a ten-minute period in the experimental boxes, Group A received simple extinction; Group B received extinction plus punishment for all responses; Group C was placed in the boxes with the levers removed, and shocks were administered at sixty second intervals. On the following day all nine animals were placed in the boxes for two hours *with the levers retracted* in order to permit adaptation of any "emotional" reaction to the experimental situation which had become conditioned as a result of the procedure of the preceding day. On the third day, the levers were returned to the boxes and each group was given an hour of extinction.

Results. The mean heights of the extinction curves obtained on the third day of the experiment proper are as follows:

Group A 77.5
Group B 88.0
Group C 66.3

The marked depression in rate of responding during the first period of extinction after punishment which was so clearly evident in Figure 3 is lacking in these data. All of the differences are statistically insignificant. Evidently the effect of a short period of punishment was dispelled by a period of exposure to the experimental situation.

TABLE 9
Summary of the procedure and quantitative results of Experiment J, Part 2

	N	Pr.	10 min. period		Amt. Adapt.	Extinction Periods						
						1	2	3	4	5	6	7
$\bar{x}_{A_0}$	5	215.6	(Pun.)	6.0	None	23.2	20.0	29.4	21.4	20.0	41.0	38.8
$\bar{x}_{B_0}$	3	222.0	(Shock)	—	None	17.7	14.0	12.7	6.0	3.3	7.3	24.0
$\bar{x}_{C_0}$	6	176.7	(Ext.)	42.8	None	99.8	52.3	59.2	42.3	52.2	57.7	64.2
$\bar{x}_{A_1}$	6	207.5	(Pun.)	4.0	1 hr.	51.7	28.8	27.5	23.8	22.8	21.2	53.8
$\bar{x}_{B_1}$	3	214.7	(Shock)	—	1 hr.	48.0	65.3	37.3	22.7	23.0	30.3	84.3
$\bar{x}_{C_1}$	5	201.0	(Ext.)	20.2	1 hr.	64.6	38.2	28.2	29.8	35.0	52.4	41.8

Part 2

Subjects and Procedure. Twenty-eight rats were first given the usual preliminary conditioning and periodic reinforcement. The animals were then subdivided into six groups matched as closely as possible on the basis of initial periodic rate and subjected to the following procedures during a ten-minute test period:

Groups A_0 and A_1: extinction with all responses punished;
Groups B_0 and B_1: periodic shocks, at sixty second intervals with levers retracted;
Groups C_0 and C_1: extinction.

On the following day, Groups A_0, B_0, and C_0 remained in the living cages; Groups A_1, B_1, and C_1 were placed in the boxes with the levers retracted, for a one-hour period of adaptation. Beginning on the third day, each group received seven one-hour periods of extinc-

tion. The first six were on consecutive days; the seventh was delayed until a week after the sixth in order to permit spontaneous recovery from extinction. The number of rats in each group is given in Table 9, along with a summary of the procedure and the quantitative results.

Results. A comparison of the two sets of curves in Figure 13[9] indicates that the

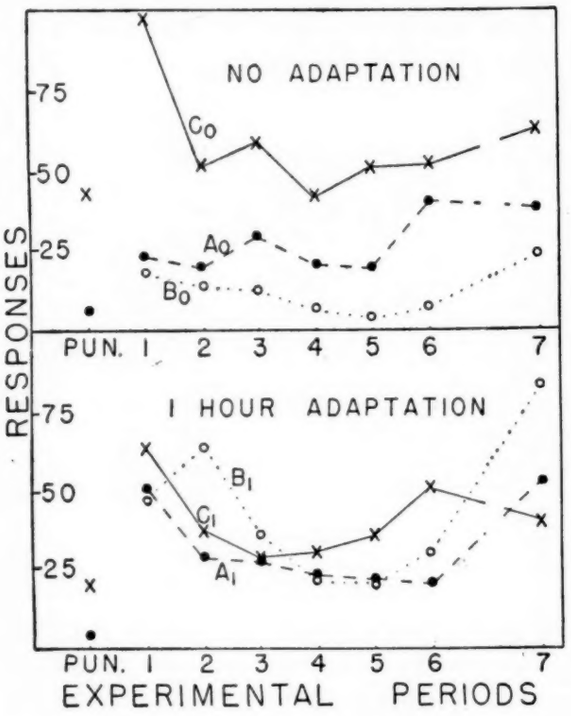

FIG. 13. Effects of a period of adaptation upon the course of recovery from punishment. During the period of 'punishment,' Groups A_0 and A_1 were punished for responding, Groups B_0 and B_1 received random shocks, Groups C_0 and C_1 received simple extinction (Experiment J).

effect of the period of adaptation was an almost complete extinction of the effects of punishment. The results of punishment without adaptation, shown in the upper panel of Figure 13, agree with those of earlier experiments (B, C, I) in showing a rather persistent depression in rate of responding during extinction. When an hour of adaptation is interpolated between punishment and extinction, however, the extinction curves of the three groups do not differ significantly (lower panel of Figure 13).

When extinction begins immediately, the group which had received periodic shocks exhibits a more prolonged depression in rate of responding than the group which had received punishment for responding; however, more complete recovery is effected after a period of adaptation in the boxes for the animals which received periodic shocks than for those which were punished. Therefore, it appears that not quite all of the effect of actual punishment is attributable merely to the correlation of the disturbing stimulus with the general stimulation from the experimental situation. The essential difference between the two procedures may lie mainly in the fact that when the shock is closely correlated with the response, the 'anticipatory' reaction to shock may be conditioned to tactual stimulation from the lever and the proprioceptive stimulation from the movements involved in pressing the lever as well as to general stimulation from the experimental situation. During the period of adaptation, then, only the latter connections are extinguished. Conditioning to specific stimulation from the lever cannot be extinguished until subsequent extinction, involving repeated elicitation of the response, is carried out. The results of the present experiment indicate, however, that during a short period of severe punishment, the conditioning of the reaction to punishment tends to be rather generalized to the whole complex of stimuli acting at the time and that little specific connection between the

[9] This experiment was conducted during the summer at a time when day to day temperature variations were unusually great. The resulting irregularity of the extinction curves precludes a very detailed analysis of the data. The general result, however, may be accepted with confidence, since the two parts of the experiment are in complete agreement. Also, the conclusions drawn from these experiments will be subjected to an additional check in Experiment K.

punishment and the response is established. Of course it does not follow from the results of this experiment that the correlation of punishment with the punished response is unimportant. Experiment K will investigate conditions under which a closer connection between the effect of punishment and the punished response can be established.

Conclusion. The effects of a short period of severe punishment upon the dynamic properties of a response are almost completely dispelled by a period during which the organism is exposed to the experimental situation but is unable to make the response. The interpretation of punishment as a process of suppression rather than extinction of the response is substantiated by the present demonstration that the principal effects of a short period of punishment can be conditioned or extinguished quite independently of the elicitation of the response.

TABLE 10
Mean periodic rates and extinction records for Experiment K

	N	Pr.	Pun.	Raw Data Extinction Periods						Pun.	Data Corrected for Periodic Rate Extinction Periods					
				1	2	3	4	5	6		1	2	3	4	5	6
$\bar{x}_A$	6	265.2	37.5	18.3	65.5	26.3	14.5	28.7	26.3	48.2	19.7	60.7	36.3	18.0	33.3	36.3
$\bar{x}_B$	6	223.3	16.5	50.8	63.7	39.5	17.2	39.2	40.0	24.2	76.2	91.5	53.5	25.3	53.7	56.0
$\bar{x}_C$	6	448.0	158.0	118.5	78.3	88.0	49.3	59.2	45.2	95.5	60.7	60.8	43.5	24.0	36.8	24.8
A–B																
t		.78	2.02	2.07	.09	1.33	.49	.74	.37	1.60	2.79	.99	1.47	1.06	.99	1.04
P_t		.45	.07	.06	.92	.20	.64	.48	.71	.14	.02	.35	.17	.31	.35	.32
A–C																
t		1.17	1.67	1.34	.51	1.09	1.07	1.07	.82	2.58	1.98	.01	.48	.76	.20	.92
P_t		.27	.13	.21	.62	.30	.31	.31	.42	.03	.08	.99	.64	.46	.85	.37
B–C																
t		1.44	1.96	.89	.56	.85	1.00	.67	.21	3.86	.57	1.24	.72	.15	1.09	1.83
P_t		.18	.08	.39	.59	.42	.34	.52	.84	.003	.59	.24	.48	.88	.30	.10

Experiment K. Periodic and Continuous Punishment Compared with Respect to the Specificity of their Effects to the Punished Response

In an earlier experiment (Experiment E) it was shown that the effects of periodic punishment tend to be more persistent than the effects of continuous punishment. In view of the results of Experiments I and J, it is possible that the greater persistence of the effect of periodic punishment may be due to the greater opportunity afforded for strong conditioning of part of the reaction to the disturbing stimulus to tactual stimulation from the lever and to proprioceptive stimulation from the movements involved in pressing the lever. (It has been well established (42) that periodic reinforcement of a response produces much greater resistance to extinction than continuous reinforcement.) If this interpretation is correct, then the interpolation between the period of punishment and the beginning of subsequent extinction of a period of adaptation to the general stimulation of the experimental situation should be expected to increase the disparity between the effects of the two procedures of punishment.

Subjects and Procedure. The eighteen rats serving as subjects in this experiment were divided after preliminary training into one control and two experimental groups of six rats each. On the first day of the experiment all three groups were placed in the experimental boxes for a forty-minute period during which Group C received extinction, Group B, extinction plus punishment for all responses, and Group A, extinction

plus periodic punishment. Under the latter procedure, the condensors were connected in circuit with the levers for one minute out of every four, during which all responses were punished; during the intervening intervals responses were neither punished nor reinforced. On the following two days, all groups were placed in the boxes for one-hour periods with the levers retracted. Beginning on the fourth day, each group received six one-hour periods of extinction.

pression in rate of responding during the period of punishment. After the two periods of adaptation to the experimental situation, however, the effects of the punishment had been almost completely dispelled, as indicated by the fact that the curve of Group B (Figure 14) nearly rejoins the control curve on the first day of extinction. The group which received periodic punishment (Group A), showed less initial effect of punishment, but exhibited little recovery from the punish-

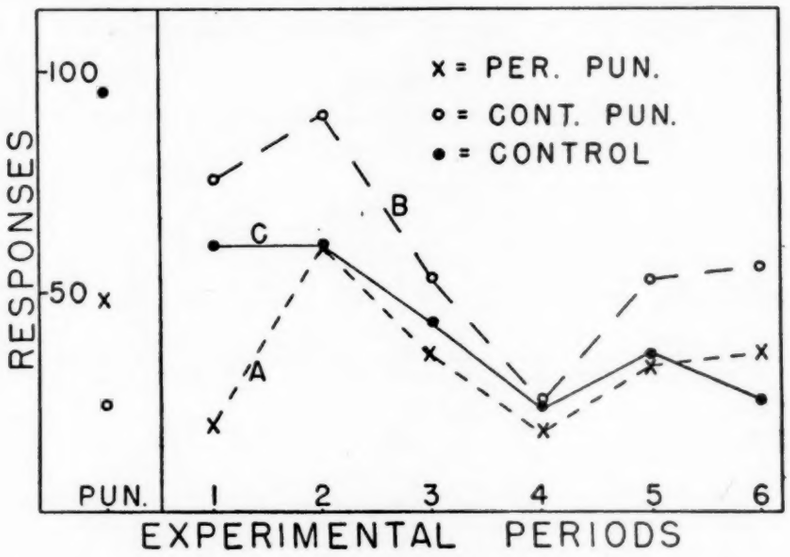

FIG. 14. Effects of a period of adaptation upon recovery from periodic as compared to continuous punishment mean curves correlated for periodic rate. (Experiment K).

Results. The quantitative results of this experiment are summarized in Table 10. Since Group C has a disproportionately high periodic rate, all comparisons are made both for the raw data and for data corrected for differences in motivational level. Although the results are not greatly different with or without the correction for motivational level, the corrected data probably give a truer picture of the influence of the variables under consideration.

Group B, which received continuous punishment on the first day of the experiment proper, exhibited the greater depression on the first day of extinction indicating that the effects of periodic punishment are more closely associated with the punished response than those of continuous punishment.

Conclusion. The results of this experiment, with those of Experiment E, show that while continuous punishment of a response produces greater initial depression in strength, periodic punishment results in a more persistent inhibitory effect during subsequent extinction. The effects of periodic punishment are more specific to the punished response than those of continuous punishment.

IV. Induction of Punishment between Dynamically Related Responses

The preceding experiments have investigated the principles governing the effects of punishment upon a single isolated response. Now, it is of interest to determine whether or not additional principles will be required to account for the action of punishment in a more complex case involving more than one response. The greatest part of the literature on experimental studies of punishment has been concerned with situations in which two alternative responses are available, one of which is arbitrarily considered 'right' and the other 'wrong', for example, studies of the effect of punishment for 'errors' in maze learning. It is likely that the apparently conflicting results of many of these studies (see, for example, 6, 52) on the question of the effectiveness of punishment are due to the fact that the experiments have typically been set up merely to determine which of two alternative responses is 'learned' rather than to trace the changes in strength of each response resulting from the punishment. In the following experiment the animals first learned to press two different levers for food reinforcement, then one response was punished, and the resulting changes in strength of both were traced through subsequent periods of extinction.

Experiment L. Effects of Punishment in a Situation Involving More Than One Response

Subjects and Procedure. The subjects were two groups of four rats. The apparatus was the same as that used in preceding experiments except for the addition of a second lever. The two levers were about two inches apart on one wall of the experimental box, one situated to the left and one to the right of the food tray. Both levers were retractable so that either could be presented alone. After preliminary conditioning, each rat was given two hours of periodic reinforcement on each lever. Since the mean rates of responding under periodic reinforcement were 152.0 responses on the left lever and 150.4 on the right lever, it can safely be assumed that the strengths of the two responses were equal. The remainder of the experiment was carried out according to the following schedule:

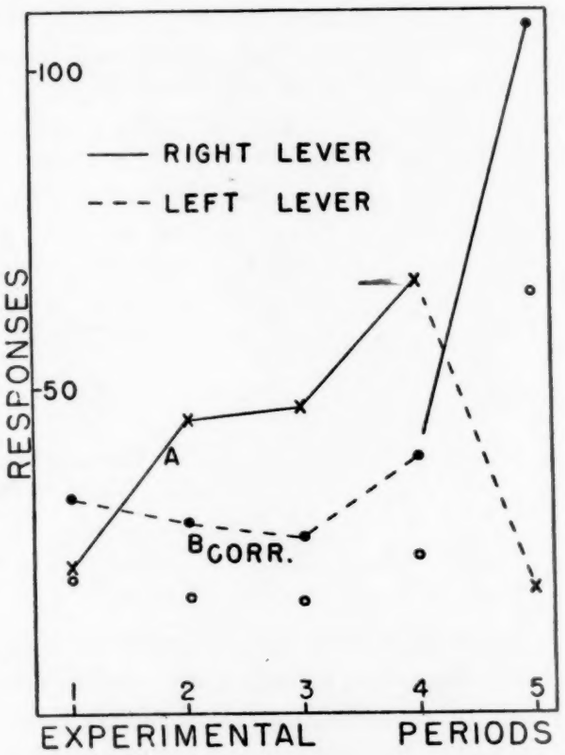

Fig. 15. Effects of punishment in a situation involving alternative responses. Prior to Day 1, each group had received periodic reinforcement on both levers, then punishment on the left lever. The corrected curve for Group B has been multiplied through by a constant chosen to equate the two groups for periodic rate. Uncorrected values for Group B are indicated by the open circles (Experiment L).

Group	10 min. pun.	Four extinction periods	Fifth extinction period
A	Left lever	Right lever	Left lever
B	Left lever	Left lever	Right lever

Results. The results of the experiment are presented in Figure 15 and Table 11. Records corrected for differences in initial periodic rate are included along with the raw data in both cases. A comparison on the fourth and fifth days for the two groups yields a value of "t" which would occur only four times in a hundred in a chance distribution. An X^2 test applied to the mean rates on the same two days yields a value of X^2 which would occur less than one time in a thousand in a chance distribution. The result is the same for the data corrected for initial periodic rate as for the raw data.

TABLE 11
Mean periodic rates and extinction records for Experiment L

	N	Pr.	Extinction Period					
			1	2	3	4	5	D_{4-5}
			Raw Data					
			R	R	R	R	L	
$\bar{x}_A$	4	220.3	22.5	46.0	47.3	67.8	48.3	+19.5
			L	L	L	L	R	
$\bar{x}_B$	4	134.9	20.8	18.3	17.0	24.8	65.3	−40.5
t		1.95	.12	1.30	1.41	1.10	.51	2.58
P_t		.10	.91	.34	.21	.31	.63	.04
			Corrected for Periodic Rate					
			R	R	R	R	L	
$\bar{x}_A$	4	220.3	22.5	46.0	47.3	67.8	48.3	+19.5
			L	L	L	L	R	
$\bar{x}_B$	4	220.3	33.9	29.8	27.7	40.4	106.4	−66.0

of the heights of the two curves on the first day in Figure 15 indicates that the initial effect of punishment is completely generalized to the unpunished response. The course of recovery during the next three periods is quite different for the two responses, however, being considerably accelerated for the unpunished response, R_R. On the fifth day of extinction, when the previously retracted lever was presented to each group, the result was a sharp rise in rate of responding for Group B which had been receiving extinction on the punished response, R_L, and a sharp decline in rate for Group A which had been receiving extinction on the unpunished response, R_R. A comparison of the differences between rates

Two relatively distinct effects of punishment can be distinguished. The first is not specific to the punished response but affects to about the same extent any behavior which would normally occur in the situation in which the punishment was administered. In this experiment, the punishment initially affected the two responses equally. But the subsequent course of recovery, and the marked changes in strength when the previously retracted levers were presented on the fifth day of extinction, show that a part of the effect of punishment is quite specific to the punished response. The recovery in strength of R_R during the first four days of extinction in the case of Group A together with the sharp rise in

rate of responding for Group B on the fifth day when the right lever was presented for the first time during extinction, show that the generalized effect of punishment upon R_R adapts out at about the same rate during subsequent periods in the experimental situation whether the response is elicited or not. On the other hand, the drop in the curve of Group A on the fifth day demonstrates that part of the effect of punishment is specific to the punished response and cannot be extinguished without unpunished elicitations of that response. It appears, then, that the effects of punishment in this situation can be completely accounted for by the principles developed in Chapters II and III.

Conclusion. If of two equally strong responses, R_1 and R_2, which have previously been reinforced in a given situation one, R_1, is punished to the point of temporary suppression, the initial effect of the punishment is completely generalized to R_2. During subsequent periods of extinction, the recovery of R_2 from the effects of punishment is considerably accelerated over that of R_1 and appears to proceed at about the same rate during periods of exposure to the experimental situation whether R_2 is actually elicited or not. As for the effect of punishment upon the punished response itself, the results of this experiment confirm the conclusion drawn from Experiment J—that partial recovery from punishment occurs during subsequent periods of passive exposure to the experimental situation but that complete recovery is contingent upon a sufficient number of actual elicitations of the response.

V. Summary of Empirical Principles

I.

When the disturbing stimulus is of sufficient intensity and is temporarily contiguous with a response and with the discriminative stimuli for the response, the immediate effect of punishment is regularly a depression in strength of the response. This effect is maintained so long as the punishment continues to be correlated with the response. However, the rate of responding at the end of a period of punishment, regardless of severity or duration, is not a reliable index of the true latent strength of the response. Discontinuation of punishment is always followed by some recovery in strength.

II.

The effects of punishment are contingent upon a close association of the disturbing stimulus with the stimuli which normally provide an occasion for the occurrence of the response (discriminative stimuli). There is no evidence that the correlation of the punishment with the response per se in the role of a 'negative reinforcement' is important.

III.

The extinction of a response which has been positively reinforced cannot be accelerated by the application of punishment; the total amount of time necessary for extinction is evidently determined by the conditions of previous positive reinforcement and cannot be reduced by punishment.

IV.

The extent to which the total number of unreinforced elicitations of a response necessary for extinction at a given level of drive can be reduced by punishment is a joint function of the conditions of punishment and the conditions of previous positive reinforcement.

A. When a response which has been strengthened by periodic reinforcement is punished for a time and then during subsequent periods is neither punished nor reinforced, the following relationships hold:

1. A period of mild punishment produces a temporary depression in rate of responding which is followed by a compensatory increase so that the total number of unreinforced elicitations necessary for complete extinction is not altered.

2. When a severe punishment is continued to the point of temporary suppression of the response, the process of recovery from the initially depressing effect of the punishment is described by an equation of the form

$$p_t = p_0 e^{-at}$$

where p_t is an index of the effect of punishment remaining at time t, p_0 is the magnitude of p during the period of punishment, and a is a constant. After recovery from the effects of punishment, there is only partial compensation for the previously depressed rate of responding.

3. When severe punishment is prolonged beyond the point of temporary inhibition, a considerable saving may be effected in the total number of unreinforced elicitations of the response necessary for extinction.

B. The proportion by which the total number of unreinforced elicitations of the response necessary for extinction can be reduced by a given condition of punishment decreases with increasing amounts of previous positive reinforcement.

V.

After the establishment of a discrimination, the initial effect of punishment of the response in the absence of the discriminative stimulus (the stimulus which provides the occasion on which the response will be reinforced) is almost completely generalized to the strength of the response in its presence. Recovery in strength of the response in the presence of the discriminative stimulus follows a course similar to that observed in the case of a response which was simply periodically reinforced for a time prior to the period of punishment. The strength of the response in the absence of the discriminative stimulus exhibits little recovery from the effects of punishment.

VI.

The immediate effect of punishment upon a periodically reinforced response is a simple change in slope of the periodic curve (i.e., a decline in strength); if reinforcement continues after the discontinuation of punishment, the effects of punishment are quickly dissipated. The effects of punishment of a response upon the course of subsequent extinction are about the same whether or not positive reinforcement continues during the period of punishment.

VII.

The result of a period during which a disturbing stimulus is associated with the stimuli which normally act as an occasion for the occurrence of the response is a depression in strength of the response during subsequent periods of extinction very similar to that produced by a period of actual punishment of the response.

VIII.

The effects of a period of severe punishment are almost completely extinguished by a period during which the organism is exposed to the experimental situation but is unable to make the response.

IX.

The effects of periodically administered punishment are more specific to the punished response than those of punishment which follows every occurrence of the response.

X.

If of two alternative responses to a situation, R_1 and R_2, which are initially of equal strength, one, R_1, is punished, the initial effect of punishment is completely generalized to R_2. During subsequent periods, the recovery of R_2 from the effect of punishment is considerably accelerated over that of R_1 and proceeds at about the same rate during periods of exposure to the experimental situation whether R_2 is actually elicited or not. As for the recovery from punishment of the punished response, R_1, it appears that partial recovery occurs during periods of passive exposure to the experimental situation, but complete recovery is contingent upon a sufficient number of actual elicitations of the response.

VI. Theoretical and Practical Implications

An Interpretation of Punishment in Terms of Emotional Conditioning and Conflict

The results of the present investigation tend, in general, to confirm Thorndike's most recent formulation of the law of effect (50). It appears that the effects of punishment upon the punished response are due to competing reactions aroused by the noxious stimulus. No evidence has been forthcoming to indicate that punishment exerts a direct weakening effect upon a response comparable to the strengthening produced by a reward. The term 'reinforcement' can best be reserved for the latter class of stimuli.

The observed facts concerning the action of punishment can be accounted for in terms of conditioning principles established by investigations of the effects of a noxious stimulus which is not correlated with a response in the role of a punishment. An experiment reported by Estes and Skinner (18) demonstrated that a tone which precedes a disturbing stimulus acquires the capacity to depress the strength of behavior normally occurring in the situation even though the behavior has never been directly associated with either stimulus. It was concluded that the tone becomes an occasion (a conditioned stimulus) for a state of 'anxiety' or anticipation of the shocks.

In an earlier investigation, Warner (58) subjected rats to repeated presentations of a CS (buzzer or light) followed by shock, under a variety of conditions and observed the reaction to the buzzer or light resulting from the conditioning. He found that no specific parts of the original response to the US, with the possible exception of autonomic reactions, such as change in breathing rate, are regularly conditioned. About all that can be said with confidence about the conditioned state of anticipation which comes to be aroused by a stimulus (S_1) which characteristically precedes a disturbing stimulus (S_2), is that it commonly involves parts of the original unconditioned reaction to S_2 together with some apparently random activity, and that it results in the disruption of the 'normal' behavior of the organism, in the situation in question so long as S_1 is present.

It is clear, then, that a disturbing or traumatic stimulus arouses a changed state of the organism of the sort commonly termed 'emotional' and that any stimulus present simultaneously with the disturbing stimulus becomes a conditioned stimulus capable of itself arousing the state on subsequent occasions. From the results of the present investigation, we may conclude that a great part of the initial effect of punishment is due to this sort of emotional conditioning. In Experiment G, in which the rats were merely given shocks while in the experimental situation, the stimuli which normally provided an occasion for the occurrence of the lever-pressing response became conditioned stimuli for anticipating the shock. When punishment is correlated with the response, emotional reaction can also become conditioned to the incipient movements of making the response. (This interpretation has been anticipated by Skinner [42].) During periods following discontinuation of punishment when the organism is exposed to the situation in which punishment occurred but is unable to make the response, the connections between the conditioned emotional state and the stimuli present in the situation are extinguished.

In addition to a generalized emotional reaction, a disturbing stimulus usually arouses a withdrawal response, R^W. It has been shown (9, 25, 26) that R^W becomes conditioned to any stimulus which is contiguous with the disturbing stimulus. In many situations involving punishment there is opportunity for R^W to become conditioned to the same stimuli which previously aroused the punished response. Part of the effect of punishment in these cases is probably a result of conflict between the competing responses. If the disturbing stimulus is of sufficient intensity, R^W becomes prepotent and the original response temporarily ceases to occur. When a child touches a hot radiator, for example, the painful stimulation causes a vigorous withdrawal from the hot object. On subsequent occasions, the sight of the radiator alone will suffice to arouse the withdrawal response which, being directly in conflict with the response of touching the radiator, prevents the occurrence of the latter. However, the present investigation has demonstrated that the original response is not eliminated from the organism's repertoire, but continues to exist at a state of considerable latent strength. Whenever punishment is discontinued, experimental extinction of R^W begins; and as R^W is weakened, the original response recovers in strength, It is likely that the superiority of periodically administered punishment over punishment which follows every occurrence of a response (noted in Experiments E and K) is due to the resulting periodic reinforcement of the response of withdrawal from the region of the lever. Skinner (42) has shown that periodic positive reinforcement of a response produces much greater resistance to extinction than continuous reinforcement. In this situation, termination of the shock presumably acts as reinforcement for the response of withdrawal from the lever.

The generalized effects of punishment are probably mediated largely by the 'emotional' reaction aroused by the noxious stimulus. This reaction should be expected to affect any behavior normally occurring in the situation and accounts for the initially complete induction of the effects of punishment between dynamically related responses noted in Chapter IV. During a period of adaptation to the situation in which punishment occurred, the connections of the conditioned emotional state to the general stimulation from the experimental situation and to stimuli produced by movements of making the response are extinguished, the former directly, the latter through induction.

PUNISHMENT IN THE PRACTICAL CONTROL OF BEHAVIOR

Probably the most important practical implication of the present study is the demonstration that a response cannot be eliminated from an organism's repertoire more rapidly with the aid of punishment than without it. In fact, severe punishment may have precisely the opposite effect. A response can be permanently weakened only by a sufficient number of unreinforced elicitations and this process of extinction cannot proceed while a response is suppressed as a result of punishment. The punished response continues to exist in the organism's repertoire with most of its original latent strength. While it is suppressed, the response is not only protected from extinction, but it also may become a source of conflict. An emotional state, such as 'anxiety' or 'dread', which has become conditioned to the incipient movements of making the response will be aroused by any stimuli which formerly acted as

occasions for the occurrence of the response.

Another disadvantage of severe punishment lies in the generalization of the conditioned emotional reaction aroused by the disturbing stimulus to other stimuli acting at the time. Whipping a dog, for example, is quite as likely to result in the conditioning of fear and withdrawal reactions to the sight of the trainer as in the weakening of the undesired behavior. And the emotional state is as effective in depressing the strength of other behavior which would normally occur in the situation in question as in depressing the strength of the punished response.

Punishment can be used profitably as an aid in the elimination of an undesired response only if the severity of the punishment is adjusted in such a manner that the response continues to occur, but at a reduced rate; under this condition, a considerable saving may be effected in the number of unreinforced elicitations of the response necessary for extinction, although the total amount of time required cannot be reduced.

In cases where the factor of reward cannot be brought under control, punishment of suitable intensity can be used to hold the response at a low strength, provided that the correlation of punishment with the response can be maintained indefinitely. It was shown in Chapter II, Section 2, that the result of directly opposed punishment and reward is an equilibrium with the resultant strength of the response a function of the relative intensities of the two factors. For any given condition of reinforcement, a condition of punishment can probably be found that will reduce the rate of responding to a very low value. The principle difficulty with this procedure is that whenever punishment ceases to be correlated with the response, the effects of the punishment are quickly dissipated.

In many instances one is interested not so much in actually eliminating a response as in supplanting an undesired response to a situation with a more acceptable one. Punishment can be usefully employed as a means of temporarily suppressing the original response while some other response is strengthened by reinforcement.

In all of these cases, punishment can be expected to weaken a response only if it is temporally contiguous with the discriminative stimuli for the response and with the movement involved in making it, or with both. Many a dog-owner has learned the futility of attempting to break the habit of chasing cars by punishing the animal when he returns from the chase and the car is out of sight. Educators and animal trainers have frequently observed that punishment is usually ineffective if delayed too long after the occurrence of the response. However, the present study has shown that it is not the correlation of the punishment with the response per se that is important, but the contiguity of the punishment with the stimuli which formerly aroused the response.

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GEORGE BANTA PUBLISHING COMPANY, MENASHA, WISCONSIN